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AGARD INDEX OF PUBLICATIONS, 1971-1973

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AGARD-INDEX

NORTH ATLANTIC TREATY ORGANIZATION

ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT

(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

AGARD INDEX OF PUBLICATIONS

1971 – 1973

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(423)

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PREFACE

This index, for AGARD publications published during the period 1971-1973, differs from previous AGARD Indexes in that the Abstract Section (Part I) and the indexes (Part II) have been consolidated under a single cover.

By an arrangement with the U.S. National Aeronautics and Space Administration in Washington, the NASA computerized data base and abstracts have been used to prepare this publication.

There are five indexes - Subject, based on NASA Thesaurus nomenclature, Personal Author, Corporate Source, Report Number and Accession Number. Sample entries will be found on the first page of each index.

The 34 NASA categories have been used for abstract location. Abstracts are arranged by series and year in each category - N10,000 Series (STAR), and X70,000 Series, in that order. Abstract lookup from the indexes has been facilitated by use of page numbers. A typical citation with abstract is located immediately after the Table of Contents.

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PART I: ABSTRACTS

Abstracts are grouped under the following subject categories

PART II: INDEXES

TYPICAL CITATION AND ABSTRACT

AVAILABLE ON MICROFICHE

NASA ACCESSION NUMBER → N74-12713# Advisory Group for Aerospace Research and Development Paris (France). ← CORPORATE SOURCE

MARKINGS FOR PROPELLER CONSPICUITY ← TITLE

AUTHOR → T. C. D. Whiteside (RAF Inst. of Aviation Med.) Sep. 1973 ← AUTHOR'S AFFILIATION

17 p refs

PUBLICATION DATE

(AGARD-AR-56) Avail: NTIS HC $3.00 ← EXCEPTION PRICING

REPORT NUMBER

AVAILABILITY SOURCE

ABSTRACT → The general problem of marking propellers so that they may be seen is discussed. The propeller must be conspicuous to persons walking near it when the aircraft is on the ground but, on the other hand, in taxying and in flight it must not be distracting or annoying to the pilot. Other factors to be considered are the conspicuity at low and at high rpm; the conspicuity against various backgrounds since markings easily visible against a dark ground may not be visible against a light ground; the use of coloured markings which, although easily seen on a stationary propeller, become desaturated when the propeller is turning, and finally, the presence of brightness and of colour contrast with the background. In theory, to obtain maximal brightness contrast, black and white markings should be used so that the blades may be seen against either light and dark background. As black matt paint may appear grey since it scatters incident light, the markings should be in a gloss finish. Author ← ABSTRACT AUTHOR

AGARD INDEX OF PUBLICATIONS (1971-1973)

PART I: ABSTRACTS

01 AERODYNAMICS

Includes aerodynamics of bodies, combinations, internal flow in ducts and turbomachinery, wings, rotors, and control surfaces. For applications see 02 Aircraft and 31 Space Vehicles. For related information see also 12 Fluid Mechanics, and 33 Thermodynamics and Combustion.

N71-17432# Advisory Group for Aerospace Research and Development, Paris (France)
MANUAL ON AEROELASTICITY: SUBJECT AND AUTHOR INDEX
E C Pike, ed Jan 1971 28 p refs
(AGARD-R-578-71) Avail NTIS
The Subject Index and Author Index cover all the chapters in the six loose-leaf volumes of the Manual on Aeroelasticity and were up to date in April 1970. Since that date new chapters of the manual have been published in the AGARD Report series. The indexes are published in two forms: in the AGARD Report series as AGARD Report 578 and in loose-leaf form for insertion in Volume VI of the Manual. Entries are given by volume, chapter and page number. For example, II/9/56 denotes Volume II, Chapter 9, page 56. The letter S after a chapter number denotes a supplement to that chapter. The letters TG denote the section of tables and graphs in Volume VI. The abbreviation INTRO denotes the introductory survey in Volume I. Author

N71-19353# Advisory Group for Aerospace Research and Development, Paris (France)
AERODYNAMIC INTERFERENCE
Jan 1971 451 p refs Presented at Fluid Dyn. Panel Specialists' Meeting, Silver Spring, Md., 28 - 30 Sep 1970
(AGARD-CP-71-71) Avail NTIS HC$6.00/MF$0.95
Aerodynamic interference characteristics of various airframe-propulsion systems for commercial transport and military aircraft are discussed. Wing-fuselage store designs and body-wing and tail configuration effects are emphasized. For individual titles see N71-19354 through N71-19388

N71-19354# Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept
SOME REMARKS ON THE INTERFERENCE BETWEEN A SWEPT WING AND A FUSELAGE
D Kuechemann *In* AGARD Aerodyn Interference Jan 1971 11 p refs (See N71-19353 09-01)
Avail NTIS HC$6.00/MF$0.95
Principal physical interference effects which occur when a swept (or unswept) wing is joined to a fuselage are analyzed. The flow is dominated by what happens in the junction between the two bodies, here the interference is largest. The leading terms in the velocity field can be interpreted as being caused in part by the interference with the mirror image in a plane wall of the half wing outside the fuselage. This reflection effect depends mainly on the sweep angle and the dihedral angle. In addition there is a body interference effect at all sweep and dihedral angles. The method of singularities is applied to calculate the inviscid flow field for some simple cases with and without lift. Theoretical and experimental results demonstrate quite clearly the magnitude of the interference effect. Author

N71-19355# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)
WIND TUNNEL INVESTIGATION OF THE VORTEX SYSTEM NEAR AN INCLINED BODY OF REVOLUTION WITH AND WITHOUT WINGS
F-H Grosche *In* AGARD Aerodyn Interference Jan 1971 15 p refs (See N71-19353 09-01)
Avail NTIS HC$6.00/MF$0.95
The flow field on the suction side of a slender body of revolution with and without wings was investigated by means of a directional probe in a 3 m x 3 m low speed wind tunnel. Measurements have been conducted at Mach numbers Ma = 0.12 and Reynolds numbers Re = 500,000, based on free stream velocity and body diameter. The model was tested at angles of attack alpha = 7 deg, 10 deg, 15 deg, 20 deg. From the measured data, the cross flow velocities and the isobars of total pressure loss were computed. Position and strength of the vortices were determined as functions of the axial coordinate. There are significant deviations from the results of measurements at high subsonic or supersonic velocities, as well as from measurements at substantially lower Reynolds numbers. The strength of the body vortices is considerably reduced by the presence of the wings. Author

N71-19356# Boeing Co., Seattle, Wash. SST Aerodynamics Configuration Group
CONSIDERATIONS OF AERODYNAMIC INTERFERENCE IN SUPERSONIC AIRPLANE DESIGN
Edward J Kane and Wilbur D Middleton *In* AGARD Aerodyn Interference Jan 1971 16 p refs (See N71-19353 09-01)
Avail NTIS HC$6.00/MF$0.95
Methods for optimizing the interferences between aircraft wing and body, wing and engine nacelles, and wing and trimming surfaces in supersonic flow are discussed. Theoretical concepts are reviewed and expanded where necessary to understand the physical relationship that leads to the most favorable arrangement of the configuration components. Specific applications are illustrated by examples employing analyses of both theoretical and experimental data. Author

N71-19357*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif

RECENT EXPERIENCE IN USING FINITE ELEMENT METHODS FOR THE SOLUTION OF PROBLEMS IN AERODYNAMIC INTERFERENCE

Ralph L. Carmichael *In* AGARD Aerodyn. Interference Jan. 1971 5 p refs (See N71-19353 09-01)
(NASA-TM-X-66884) Avail NTIS CSCL 20D

Discrete sets of elementary solutions of the linearized equations of gas dynamics for solving problems of flow about airplane configurations are combined in such a way that the boundary conditions of zero flow through physical surfaces are satisfied at large numbers of control points on the surfaces. Calculations using discrete elements and discrete control points produce solutions consistent with closed-form solutions that satisfy the boundary conditions everywhere. An existing computer program for predicting the flow about simple wing-body combinations is extended to include bodies other than the main fuselage. Author

N71-19358# National Physical Lab., Teddington (England) Aerodynamics Div.

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF WING BODY CONFIGURATIONS AT LOW SUPERSONIC SPEEDS

J. Bridgewater, R. C. Lock, and G. F. Lee *In* AGARD Aerodyn. Interference Jan 1971 11 p refs (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

Wing-body combinations with modifications to the shapes of the basic bodies, wing leading edges and wing roots for reduced drag at transonic and low supersonic speeds were studied. Force and pressure measurements are given for a 55 deg swept wing mounted in turn on two asymmetrically waisted bodies. The first body was designed with the aid of the transonic area rule, and the second was a modified version of this design to give improved performance at low supersonic speeds. Additional experimental results are presented for a second wing having a much blunter leading edge shape so as to give a peaky type of pressure distribution in place of the roof-top pressure distribution of the first wing. Finally considered is the blending of varying wing section shapes near the root of swept wings at supersonic speeds in order to achieve a favorable combined wing-body pressure field inboard on the wind, thus offering the possibility of drag reduction without the use of body waisting. Author

N71-19359# Technische Hogeschool, Delft (Netherlands)

LIFT AND DRAG CHARACTERISTICS OF DELTA WING HALF CONE CONFIGURATIONS WITH SUBSONIC LEADING EDGES, USING SLENDER BODY THEORY

W. J. Bannink and J. W. Reyn *In* AGARD Aerodyn. Interference Jan 1971 11 p refs (See N71-19353 09-01)
Avail NTIS HC$6.00/MF$0.95

Configurations composed of a cone with a half-circular cross section mounted asymmetrically with respect to a delta wing of zero thickness with subsonic leading edges and placed in a supersonic flow, are studied using slender body theory. The lift and drag characteristics are compared to those of configurations having an identical wing and a symmetrically disposed circular cone of equal volume as the half cone. A disposition of a half cone on one side of the delta wing shows a drag reduction at a given lift compared to the symmetrical full cone configuration, provided the body diameter-wing span ratio is larger than 0.45 approximately. However, the high wing disposition is preferable to the low wing, since lower angles of incidence are required to attain a certain lift. Below the ratio of 0.45 the symmetrical system appears to be more favorable. The lift curve slopes of asymmetrical configurations studied are larger than those of symmetrical configurations. Author

N71-19360# Messerschmitt-Boelkow G.m.b.H., Munich (West Germany)

DOWNWASH INVESTIGATIONS ON TAILS OF MISSILES

G. Gregoriou and I. Laude (DFVLR, Brunswick, West Germany) *In* AGARD Aerodyn. Interference Jan 1971 14 p refs (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

A numerical method was developed to calculate the downwash and hence the forces and moments on missile tails. This method is principally based on the linear lifting surface theory and can be applied in the compressible subsonic range at any angle of attack and bank. The results of the calculation indicate a nonlinear dependence of the average downwash angle on the angle of attack. Generally, theoretical results show good agreement with wind tunnel tests. Author

N71-19361*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EXTENSION OF A NUMERICAL SOLUTION FOR THE AERODYNAMIC CHARACTERISTICS OF A WING TO INCLUDE A CANARD OR HORIZONTAL TAIL

Barrett L. Shrout *In* AGARD Aerodyn. Interference Jan 1971 12 p refs (See N71-19353 09-01)
(NASA-TM-X-66886) Avail NTIS CSCL 20D

A method for predicting the aerodynamic lifting surface characteristics of wing-horizontal tail configurations or canard wing configurations at supersonic speeds is discussed. The numerical solution has been programmed for a digital computer and is part of a complex of computer programs used in the design, optimization, and evaluation of aircraft configurations at supersonic speeds. The present method predicts lift, drag, and moment characteristics over a range of lift coefficients and for various control settings. Theoretical and experimental data are compared for wing-horizontal tail configurations and for canard-wing configurations at various Mach numbers. These comparisons show both the basic data with control deflections and some final trimmed drag polars. Some data are also presented to show the extent to which program limitations affect the accuracy of the analytic methods. Author

N71-19362# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

CALCULATION OF AERODYNAMIC INTERACTIONS BETWEEN LIFTING ELEMENTS OF AN AIRPLANE IN SUPERSONIC STATIONARY OR NONSTATIONARY FLOW [CALCUL D'INTERACTIONS AERODYNAMIQUES ENTRE LES ELEMENTS PORTANTS D'UN AVION EN ECOULEMENT SUPERSONIQUE STATIONNAIRE OU INSTATIONNAIRE]

Michel Enselme, Jean-Paul Boisseau, and Andre Guillois *In* AGARD Aerodyn. Interference Jan 1971 7 p refs In FRENCH; ENGLISH summary (See N71-19353 09-01)
Avail NTIS HC$6.00/MF$0.95

After recalling the principle of analog computation of a lifting assembly in supersonic steady or unsteady flow a numerical process is presented that uses an explicit method for computing the solutions of the wave equation. Results obtained either by analog or by numerical computations are presented for wing-body or wing-pod interactions and for a wing of arbitrary planform in unsteady flow. Author

N71-19363# Naval Ship Research and Development Center, Washington, D.C.

THE EFFECT OF ANGLE OF ATTACK ON INDUCED ROLLING MOMENT FOR A LOW ASPECT RATIO MISSILE

Raymond P. Le Beau *In* AGARD Aerodyn. Interference Jan 1971 11 p refs (See N71-19353 09-01)
Avail NTIS HC$6.00/MF$0.95

Two wind tunnel tests were conducted to examine the characteristics of the induced rolling moment of two small span missile configurations at transonic Mach numbers for angles of attack up to 90 deg. The induced rolling moment at a roll angle of 22.5 deg was found to increase with angle of attack to a peak value then remain near that value to 90 deg. This peak occurred

at angles between 25 deg and 40 deg. It was also observed that negative values of induced rolling moment at a roll angle of 22.5 deg occurred for one configuration when the angle of attack was less than 20 deg. Author

N71-19364# National Aerospace Lab., Amsterdam (Netherlands). Dept for Theoretical Aerodynamics.

AN APPROXIMATE METHOD FOR THE CALCULATION OF THE PRESSURE DISTRIBUTION ON WING BODY COMBINATIONS AT SUBCRITICAL SPEEDS

Th. E. Labrujere, W. Loeve, and J. W. Slooff *In* AGARD Aerodyn. Interference Jan. 1971 17 p refs (See N71-19353 09-01)

Avail. NTIS HC$6.00/MF$0.95

A method is described which makes it possible to calculate accurate pressure distributions on lifting configurations at Mach numbers up to the critical value. The compressible flow around a configuration is related to an incompressible flow by means of Goethert's rule, which is supplemented semi-empirically. The iterative scheme for solving the large system of linear, simultaneous equations that is involved with the incompressible flow problem is optimized. Assuming a simple wake configuration, the method has been applied to a number of lifting wing-body combinations. Comparisons with measured pressure distributions show that the method can be used when studying wing-body interference problems in subcritical, attached flow. Author

N71-19365# Naval Ordnance Lab., White Oak, Md.

AERODYNAMIC INTERACTION PHENOMENA PRODUCED BY A FIN PROTUBERANCE PARTIALLY IMMERSED IN A TURBULENT BOUNDARY LAYER AT MACH 5

Allen E. Winkelmann *In* AGARD Aerodyn. Interference Jan. 1971 12 p refs (See N71-19353 09-01)

Avail: NTIS HC$6.00/MF$0.95

Various flow visualization results are presented for a cylindrically blunted, unswept, unyawed fin partially immersed in a turbulent boundary layer. The model, consisting of a fin-flat plate combination, was mounted on the test plate nozzle wall of a boundary layer channel. Experiments were completed at a nominal Mach number of 5 and nominal free-stream Reynolds numbers per foot of 2.8 x 1 million and 7.4 x 1 million. Azobenzene tests show regions of high heat transfer to occur on the flat plate immediately upstream and downstream of the fin. Oil smear tests show in detail the surface shear directions and locations of separated flow which occur on the model. Schlieren and shadowgraph photographs indicate the complex shock wave structure which exists in front of the fin. Author

N71-19366*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FLIGHT AND WIND TUNNEL INVESTIGATION OF INSTALLATION EFFECTS ON UNDERWING SUPERSONIC CRUISE EXHAUST NOZZLES AT TRANSONIC SPEEDS

Daniel C. Mikkelson and Bernard J. Blaha *In* AGARD Aerodyn. Interference Jan. 1971 10 p refs (See N71-19353 09-01)

(NASA-TM-X-66887) Avail: NTIS CSCL 20D

A combined flight and wind tunnel test program is being conducted utilizing a modified F-106 aircraft, to investigate airframe installation effects on exhaust nozzle systems mounted on underwing engine nacelles. Flight tests in the transonic speed regime determined nozzle performance and boattail drag for variable flap ejector, conical plug, and auxiliary inlet ejector nozzle concepts. Wind tunnel tests were conducted on isolated models of these nozzles and also on a 1/20-scale model of the F-106 aircraft with simulated underwing engine nacelles. Wing and nacelle pressures from these wind tunnel tests are used to qualitatively explain the observed installation effects. The 1/20-scale model was also used to evaluate the effects of changes in nacelle geometry and angle-of-attack. Author

N71-19367# National Aeronautical Establishment, Ottawa (Ontario).

THE HALF CONE PRESSURE FIELD AND ITS SIGNIFICANCE TO SIDE MOUNTED INTAKES

D. J. Peake, D. J. Jones, and W. J. Rainbird *In* AGARD Aerodyn. Interference Jan. 1971 12 p refs (See N71-19353 09-01)

Avail: NTIS HC$6.00/MF$0.95

The supersonic, inviscid flow field about an isolated half cone has been computed and the result applied to a semi cone intake mounted adjacent to an aircraft fuselage. The pattern of the intake external flow was obtained from an aircraft model tested in a Mach number M = 1.8 airstream, incorporating a 25-degree semi-angle half cone. The fuselage boundary layer approaching the intake was turbulent, corresponding to a Reynolds number of 0.8 x 1 million based upon the intake capture dimension. The strong, three dimensional character of the interactions that occur between the intake shock system and the fuselage boundary layer imply that any boundary layer control system must be designed to remove the effects of three dimensional rather than two dimensional separations. Author

N71-19368*# National Aeronautics and Space Administration. Langley Research Center, Langley, Va.

AERODYNAMIC INTERFERENCE BETWEEN EXHAUST SYSTEM AND AIRFRAME

Jack F. Runckel *In* AGARD Aerodyn. Interference Jan. 1971 13 p refs (See N71-19353 09-01)

(NASA-TM-X-66808) Avail: NTIS CSCL 01A

Mutual aircraft afterbody and engine nozzle interferences are studied by a model experimental investigations of jet interference at subsonic, transonic, and supersonic speeds. Emphasis is placed on twin-engine fuselage configurations with nozzles installed near the terminus of the afterbody where the interactions of the nozzle exhausts and the external stream produce a complex flow field environment. Airframe interferences on nozzle performance considered are installation locations in the afterbody, boattailing ahead of the nozzles, and effects of tails and protuberances. Nozzle shape and jet exhaust interference can alter aircraft performance and stability. The effect on afterbody drag of nozzle exit axial location appears to pose more problems than the lateral spacing of the nozzles. For closely spaced nozzles, the shape of the interfairing between the nozzles has a pronounced effect on afterbody and nozzle performance. Author

N71-19369# General Electric Co., Cincinnati, Ohio.

AIRFRAME/PROPULSION SYSTEM INTEGRATION ANALYSIS USING THE PROPULSION SIMULATOR TECHNIQUE

John T. Kutney *In* AGARD Aerodyn. Interference Jan. 1971 21 p refs (See N71-19353 09-01)

Avail: NTIS HC$6.00/MF$0.95

The propulsion simulator technique was conceived to provide the analysis and evaluation of the total system performance in the wind tunnel of the new high bypass turbofan installations. This technique provides simultaneous simulation of the induction system and the exhaust system flows with correct geometric simulation and allows the total aircraft aerodynamics and the propulsion system interactions to be evaluated together without the use of additional or reference models. Examples of these data are presented including comparison of a C5A type scale model and full scale results of the TF39/B52 installation. The use of this technology for advanced programs of airframe engine integration for both the subsonic and supersonic flight spectrums is discussed. Author

N71-19370# Tennessee Univ., Tullahoma. Space Inst.

UNSTEADY AERODYNAMICS OF ROTOR BLADES OF A COMPRESSOR UNDER DISTORTED FLOW CONDITIONS

B. H. Goethert and K. C. Reddy *In* AGARD Aerodyn. Interference Jan. 1971 13 p refs (See N71-19353 09-01)

Avail: NTIS HC$6.00/MF$0.95

A theoretical investigation was undertaken to determine the interference effect between oscillating and distorted inlet flow and compressor stall. It was found that the dynamic effects on the single stage characteristics tend to make the stages less sensitive to pressure oscillations since the flow lacks the necessary time for building up the lift of the individual blades of the stage. On the other hand, the spacer volume in the stages themselves and between the stages produce time lags which tend to increase the stage pressure ratio and thus reduce the stall margin of the individual stages. Depending upon the geometry and the type of oscillations, either the beneficial effect of the dynamic response reduction of individual stages at higher frequencies or the detrimental effects of the spacer volume between the stages will prevail.
Author

N71-19371*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
STUDIES OF AIRCRAFT FLOW FIELDS AT INLET LOCATIONS
Lyndell S. King and Terence W. Schmidt (Arnold Res. Organ., Inc.) *In* AGARD Aerodyn. Interference Jan 1970 10 p refs (See N71-19353 09-01)
(NASA-TM-X-66885) Avail: NTIS CSCL 20D

A wind-tunnel investigation of the flow fields about fuselage configurations at transonic and supersonic speeds and at angles of attack up to 24 deg is reported. A family of seven fuselages with different cross sectional shapes was tested in conjunction with two nose shapes, two canopies, and two wings of different sweep. Flow field surveys were performed at two likely inlet locations – ahead of and under the wing – to assess the effects of forebody geometry throughout the Mach number and angle-of-attack envelope. The experimental data particularly indicate the strong influence of the canopy, nose droop, and fuselage shape on flow angularities in the forward survey plane. Nose droop and the canopy both tend to reduce sensitivity to positive angles of attack and to reduce the extent of influence of fuselage lower corner geometry. Under the wing, however, the flow field is dominated by the effects of the wing itself.
Author

N71-19372# National Gas Turbine Establishment, Pyestock (England).
SOME RECENT RESEARCH ON SUPERSONIC INTAKES AT NGTE
M. C. Neale and F. W. Armstrong *In* AGARD Aerodyn. Interference Jan 1971 18 p refs (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

Drag investigations covering both supersonic and subsonic flight conditions are described, and attention is focused on the difficulty of minimizing supersonic pre-entry drag while retaining an adequate stability margin. The effects are shown of shear planes of varying strength generated in the supersonic compression field. Reynolds number effects are also described. A brief survey of prospects for mixed compression intakes offering an optimum combination of drag and high pressure recovery in supersonic flight is included.
Author

N71-19373# Boeing Co., Seattle, Wash. Supersonic Transport Div.
CONFIGURATION ASPECTS OF PROPULSION INSTALLATION ON SUPERSONIC TRANSPORTS
Albert A. Van Duine, William W. Rhoades, and Walter C. Swan *In* AGARD Aerodyn. Interference Jan 1971 8 p (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

Intake decision closely related to configuration effects are outlined for supersonic transport applications. The general problems of propulsion pod placement and proper integration of pod and wing are discussed. The effects of wing flow field and aircraft maneuvers on intake performance and intake operating envelope are treated. Intake-to-intake and intake-to-wing spacing criteria are established relative to mutual intake interference and wing/body boundary layer effects. Finally, a propulsion comparison is made between a variable sweep configuration employing double engine pods and a fixed wing configuration employing single engine pods.
Author

N71-19374# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).
JET SIMULATION AND JET INTERFERENCE EFFECTS ON TAILPLANE
W. Geissler and R. Wulf *In* AGARD Aerodyn. Interference Jan. 1971 12 p refs (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

Extensive wind tunnel tests with jet simulation have been carried out in the low speed wind tunnel on different models of the European airbus. Bypass engines able to simulate the correct ratios of jet to freestream velocity have been developed and are described. The results of force and downwash measurements show destabilizing influences of the airplane caused by jet-tailplane interference. Several steps have been undertaken in order to minimize these effects: the displacement of the engines in wing-tip direction seemed to be the best solution of this problem. In addition to force measurements on a complete model the determination of magnitude and direction of the flow velocities established the boundaries of jet influence.
Author

N71-19375# British Aircraft Corp., Weybridge (England). Aerodynamics Dept.
THE COMPLEX AERODYNAMIC INTERFERENCE PATTERN DUE TO REAR FUSELAGE MOUNTED POWERPLANTS
P. R. G. Williams and D. J. Stewart *In* AGARD Aerodyn. Interference Jan. 1971 15 p ref (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

The complex interference effects due to rear fuselage mounted power plants on modern high subsonic aircraft are investigated. Results from wind tunnel and full scale flight tests obtained during design and development of BAC VC10 and 1-11 are discussed. Of particular interest are the favorable interference on the wing and comparisons between twin and four-engined configurations. The influences of changes in fuselage length, nacelle setting and rear fuselage shaping to reduce adverse pressure fields are illustrated. Typical pressure distributions and boundary layer traverses measured on the standard and super VC10 in flight are presented and comparisons are made with wind tunnel results. The data presented are evaluated for the probable mechanism of the complex interference forces set up by the presence of the power plants.
Author

N71-19376# General Dynamics/Convair, San Diego, Calif.
EXPERIMENTAL RESULTS OF HIGH BYPASS RATIO TURBOFAN AND WING AERODYNAMIC INTERFERENCE
J. E. Aldridge and J. L. Nye (GE) *In* AGARD Aerodyn. Interference Jan. 1971 12 p (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

Results of a wind-tunnel investigation into the interference effects of a pylon-wing-mounted, high-bypass-ratio turbofan on the aerodynamic characteristics of a twin engine subsonic airplane are presented. This was accomplished using a high-pressure, air turbine powered propulsion simulator mounted on a 1/7-scale semispan model of the airplane. Results show that significant interference does exist, and that it varies with free stream Mach number, engine power setting, and lift coefficient. Generally, the drag due to nacelle/body interference increases with Mach number, decreases as engine power is increased and optimizes with lift coefficient. The interference level is either favorable or unfavorable depending on these parameters. The presence of the nacelle has no measurable effect on wing upper surface pressure distribution, however, wing lower surface, nacelle fan, and turbine cowl distributions are significantly altered.
Author

N71-19377# Douglas Aircraft Co., Inc., Santa Monica, Calif.
DETERMINATION OF LOW SPEED INTERFERENCE EFFECTS BY SUPERPOSITION
John L. Hess and Suzanne M. Faulkner *In* AGARD Aerodyn Interference Jan. 1971 15 p refs (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

The application of a computer program for potential flow to problems of estimating aerodynamic interference is reported. Examples are presented of straightforward use of the program to calculate flow about more complicated configurations than could previously be handled. Superposition is also used to conserve computing time. The program greatly expands the usefulness of the superposition method. First, the component flows to be superposed may be any of the very general class of solutions that the program can calculate. Second, by comparing flows calculated by superposition with the same flows calculated exactly by the program, the limits of validity of the superposition principle can be determined with a new precision. Examples are presented of calculated flow fields and of comparisons of exact and superposed solutions. Author

N71-19378# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
WIND TUNNEL INVESTIGATION INTO AERODYNAMIC INTERACTIONS INDUCED BY DROP LOADS [ETUDE EN SOUFFLERIE DES INTERACTIONS AERODYNAMIQUES DUES AUX CHARGES LARGABLES]
J. Christophe and J. Coste *In* AGARD Aerodyn Interference Jan. 1971 11 p refs In FRENCH; ENGLISH summary (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

Techniques for the investigation of aerodynamic interactions induced by drop loads are reviewed and some representative results are reported. Emphasis is placed on direct tracings of dropped load trajectories and microrocket propelled missiles by high speed filming in the wind tunnel. Obtained results are compared with those from the newly developed alternative method of weighing the load in the aerodynamic field of the aircraft and reconstructing its trajectory by computing routine. Author

N71-19379# Nielson Engineering and Research, Inc., Palo Alto, Calif.
A CALCULATIVE METHOD FOR PREDICTING STORE SEPARATION TRAJECTORIES AT SPEEDS UP TO THE CRITICAL SPEED
Jack N. Nielson, Frederick K. Goodwin, and Marnix F. E. Dillenius *In* AGARD Aerodyn Interference Jan. 1971 14 p refs Sponsored by AFFDL (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

A theory has been developed for predicting the trajectories of external stores dropped from high-speed aircraft up to the critical speed. The method consists of three steps: (1) prediction of the non-uniform flow field in the vicinity of the store, (2) prediction of store forces and moments in the nonuniform flow field, and (3) calculation of the trajectory. A vortex lattice method used for the first step predicts well the flow field velocity components under the wing or fuselage. A simplified slender body method for calculating the normal force and moment on the external store is moderately successful by comparison with experiment. Calculated trajectories based on the simplified method are in fair agreement with experiment. Author

N71-19380# Aircraft Research Association, Ltd., Bedford (England)
EXAMPLES OF AIRFRAME STORE INTERFERENCE
J. B. Berry *In* AGARD Aerodyn Interference Jan. 1971 12 p refs (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

Effects of airframe-store interference on the side force and the drag increment due to pylon mounted underwing stores are discussed. The main features of the sidewash and pressure distributions in the flow field beneath a swept wing are described. It is noted that, while the loads on a store would be expected to vary significantly with its position under the wing, some of the interference forces may be regarded as buoyancy effects, implying opposing forces on the aircraft. Examples of measured side force on stores and pylons show that a qualitative correlation can be obtained with underwing sidewash data. Comparisons of the axial force on stores and pylons and the drag increment with estimates of the freestream drag of the store assembly, are presented and, at low speed and low to moderate C, these demonstrate the expected cancellation of some of the interference forces. Brief descriptions of methods being developed for the prediction of store and pylon side force and installed drag increment are included. Author

N71-19381# McDonnell Aircraft Corp., St. Louis, Mo.
EVALUATION OF THE PREDICTION OF AIRPLANE STORE INTERFERENCE BY LINEAR THEORY
Gordon G. Grose and Dean R. Bristow *In* AGARD Aerodyn Interference Jan. 1971 12 p refs (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

A ring-body analysis computer program is used to calculate the interference flow field at a store location due to a wing-body combination, and the resulting loads applied to the store. Interference loads predicted by linear theory are compared with test data on typical fighter bomber configurations at subsonic and supersonic speeds. The subsonic case consists of stowed load wind tunnel data on a body representing the SUU-16A gun pod mounted on the outboard wing pylon of the F-4C airplane. The supersonic case consists of loads on a sting supported store model in the vicinity of a swept wing-body combination representing a fighter bomber at Mach 1.6. The results of the comparison show the detailed survey of the interference flow field provided by the method, and indicate that it is a promising method of estimating store interference effects from the airplane geometry. Author

N71-19382# Breguet-Aviation, Paris (France)
ANALYSIS OF THE EFFECTS OF EXTERNAL STORES FASTENED UNDER AN ARROW WING ON THE LONGITUDINAL STABILITY OF THAT AIRCRAFT [ANALYSE DE L'INFLUENCE DE CHARGES EXTERNES FIXEES SOUS LA VOILURE D'UN APPAREIL A AILE EN FLECHE SUR LA STABILITE LONGITUDINALE DE CET AVION]
R. Taisserre *In* AGARD Aerodyn Interference Jan. 1971 13 p In FRENCH; ENGLISH summary (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

Wind tunnel test results show that external stores fastened under a swept wing by pylons decrease longitudinal stability of the aircraft. Most of this stability loss comes from the increased deflection of the horizontal tail due to vortice field development at the pylon's trailing edge; this is caused by the force of the local sideslip at the lower part of the wing that produce a lateral lift force on the pylon. The deflection changes the stability of the aircraft as a function of the angle of attack. Author

N71-19383# Boeing Co., Wichita, Kans.
SEPARATION CRITERIA FOR DENSELY PACKED STORES IN BOMB BAYS
Richard B. Holloway, Donald L. Sutcliffe, and James D. Woodward *In* AGARD Aerodyn Interference Jan. 1971 10 p (See N71-19353 09-01)
Avail: NTIS HC$6.00/MF$0.95

Separation characteristics of the weapons in the densely packed B-52 bombing system configuration 1224-7 proved to be

dependent on the release sequence, release interval and release airspeed. Several different release sequences were investigated to solve bomb collision problems. A successful sequence was derived which provided satisfactory bomb release characteristics when a minimum clearance of one bomb diameter between adjacent bombs is provided as the bomb clears the guide rails. Flight tests indicated the optimal performance of a three-bay configuration with a minimum release interval of 80 to 50 milliseconds. Author

N71-19384# Royal Aircraft Establishment, Farnborough (England)
FLIGHT INVESTIGATION OF A TECHNIQUE FOR THE MEASUREMENT OF THE TOTAL AND INTERFERENCE DRAG OF EXTERNAL STORES
K P King *In* AGARD Aerodyn Interference Jan 1971 13 p refs (See N71-19353 09-01)
Avail NTIS HC$6 00/MF$0 95

Results are given of the flight investigation of a technique for the measurement of the drag of external stores which can be jettisoned. The technique is to drop the stores and evaluate the store drag from the resultant change in aircraft acceleration along the flight path. In an exploratory series of tests, 1000 lb bombs were dropped from a Hunter aircraft and the variation of the drag due to the stores as they separated from the aircraft was determined. The results indicate that, with this particular aircraft/store combination, there is no significant variation of the total installed drag with C sub L over the range tested but the interference drag varies linearly with C sub L squared. Author

N71-19385# General Dynamics/Pomona, Calif
A METHOD FOR PREDICTING INTERFERENCE FORCES AND MOMENTS ON AIRCRAFT STORES AT SUBSONIC SPEEDS
F D Fernandes *In* AGARD Aerodyn Interference Jan 1971 9 p refs (See N71-19353 09-01)
Avail NTIS HC$6 00/MF$0 95

A method is developed for theoretically predicting the loading on aircraft stores at separation for subsonic flow. The method consists of predicting the flow field about the aircraft by using singularity distributions to represent the aircraft according to linear theory, the effect of the variable interference flow field is integrated over the store by using the free-air load distribution properties of the store locally. Buoyancy effects are included. The loading over each store fin is given special consideration with regard to its interaction with the aircraft pylon and with other store surfaces. A FORTRAN computer program performs the calculations. Effects of aircraft wing, fuselage, pylons, and inlets are included. Store moment calculations under an F-4C aircraft are compared with test data. Author

N71-19386# Naval Ship Research and Development Center, Washington, D C
A STUDY OF CAPTIVE FLIGHT DRAG AND SEPARATION CHARACTERISTICS OF LIFTING BODY (HALF BOMB AND HALF POD) STORE CONFIGURATIONS
Roger J Furey and C Joseph Martin *In* AGARD Aerodyn Interference Jan 1971 11 p refs (See N71-19353 09-01)
Avail NTIS HC$6 00/MF$0 95

The use of lifting bodies as a basic shape for externally carried stores is considered as a means of overcoming the large incremental drag and poor separation qualities of the more conventionally shaped aircraft stores. Wind-tunnel tests were conducted on a half-bomb and a half-pod to determine their captive flight drag and separation characteristics. Testing was conducted at Mach numbers of 0 74 and 1 88. The half-bombs were found to have as much as a 35 percent drag reduction, in a simulated captive flight condition, over its equivalent whole-bomb counterpart, and separated cleanly without the use of an ejection force under all conditions tested. The half-pod configuration produced as much as a 20 percent drag reduction over that of the equivalent whole-pod. It also separated cleanly although an ejection force was necessary in order to prevent a pitch-up maneuver and possible collision at the higher Mach number. Author

N71-19387# Naval Ordnance Lab , White Oak, Md
AIRCRAFT/STORE INTERFERENCE
Chris A Kalivretenos *In* AGARD Aerodyn Interference Jan 1971 16 p refs (See N71-19353 09-01)
Avail NTIS HC$6 00/MF$0 95

A series of tests relating to the carriage and separation characteristics of a newly developed rocket launcher pod are reported. The objectives of the tests were to identify those flight conditions under which separation of the launcher might result in damage to the aircraft and to obtain data from which the separation behavior could be predicted. Included in this series of tests was a pod installation force test, a flow-field survey test and a pod jettison test. In each investigation, the loaded and empty rocket launcher pods were suspended from the centerline and outboard shoulder stations of the scaled triple ejector rack located on the inboard wing station of an A-4 aircraft model. The pod tends to pitch nose upward at high aircraft angles of attack and nose downward at low aircraft angles of attack. In full-scale tests the nose of the empty pod collides with the wing of the aircraft when launched from the shoulder station at airspeeds below 250 knots and the tail impacts the rack when launched from the centerline at airspeeds above 450 knots. Author

N71-19388# Naval Ship Research and Development Center, Washington, D C
PREDICTION OF STORE LAUNCH CHARACTERISTICS THROUGH STATISTICAL METHODS
Michael A Sekellick *In* AGARD Aerodyn Interference Jan 1971 11 p refs (See N71-19353 09-01)
Avail NTIS HC$6 00/MF$0 95

Two statistical methods are presented which have the capability of generating equations to predict the separation characteristics of airborne stores from aircraft. A mathematical relation was found between a configuration, the launch conditions and the associated trajectory. The aircraft/store combination was described by parameters representing the important geometric and physical features which affect separation behavior. Each launch event was catalogued in terms of such parameters and the resulting separation behavior. This data was then statistically analyzed to predict the outcomes of untried launch situations. Author

N71-23210# Advisory Group for Aerospace Research and Development, Paris (France)
FREQUENCY RESPONSE FUNCTIONS AND HUMAN PILOT MODELLING
Mar 1971 65 p refs Mostly in ENGLISH partly in FRENCH (AGARD-R-580-71) Avail NTIS

CONTENTS

N71-23211# Aeronautical Research Associates of Princeton, Inc., N.J.

THE ART OF DETERMINING GUST FREQUENCY RESPONSE FUNCTION

John C Houbolt *In* AGARD Freq Response Functions and Human Pilot Modelling Mar 1971 p 1 20 refs (See N71-23210 12-01)

Avail NTIS

The art of determining the frequency response function for gust response, and of deriving the associated structural response parameters A and N sub o is discussed Measured and computed values are compared to show the degree of success obtained It is brought out that frequency response determination is a computationally large task and that simplified procedures are needed Emphasis is also given to the fact that there is not a frequency response function for the airplane but that there are many depending on flight conditions A procedure is suggested for helping to establish the appropriate frequency response functions, and the A and N sub o values for use in design Author

N71-23212# Boeing Co Wichita, Kans

THE EFFECT OF ACTIVE CONTROLS ON STRUCTURAL RESPONSES

Clifford F Newberry, James I Arnold and Gerald J Kass *In* AGARD Freq Response Functions and Human Pilot Modelling Mar 1971 p 21 44 refs (See N71-23210 12-01)

Avail NTIS

The use of an active control system on large flexible aircraft to improve flying qualities, ride qualities, and to alleviate loads require a good mathematical model The number of modes to be included is treated from a standpoint of stability and for structural loads evaluation The verification of the model during flight testing is discussed Frequency response, transient response and random response techniques are presented Presented are two examples one dealing with a lower structural mode frequency that affects the handling qualities and ride qualities of the aircraft and the other deals with a higher frequency mode that is a stability problem Consideration for artificial damping of the flutter mode is also presented Author

N71-23213# Office National d Etudes et de Recherches Aerospatiales, Paris (France)

TRANSFER FUNCTIONS OF FLEXIBLE AIRCRAFT TO ATMOSPHERIC TURUBLENCE [FONCTIONS DE TRANSFERT D'UN AVION SOUPLE A LA TURBULENCE]

G Coupry *In* AGARD Freq Response Functions and Human Pilot Modelling Mar 1971 p 45 48 refs In FRENCH (See N71-23210 12-01)

Avail NTIS

Computation and measurement of the transfer function of an aircraft flexible to atmospheric turbulence are reported After a survey of the usable turbulence models, the computation of the transfer function for isotropic turbulence is discussed, it is shown that it is hardly more complicated than in the case of uniform turbulence Finally, the methods for measuring the transfer function are described Author

N71-23214# Royal Aircraft Establishment Farnborough (England) Human Factors Group

HUMAN PILOT MODELLING

H F Huddleston *In* AGARD Freq Response Functions and Human Pilot Modelling Mar 1971 p 59 65 refs (See N71-23210 12-01)

Avail NTIS

Human factors engineering attempts to define pilot transfer functions are considered Input output engineering studies show that man as a tracker (1) behaves like a low pass amplifier (2) has a built in reaction time delay (3) can in some circumstances generate substantial lead or lag characteristics and (4) behaves as if he responded to some events about twice a second Author

N71-29333# Advisory Group for Aerospace Research and Development, Paris (France).

SYMPOSIUM ON UNSTEADY AERODYNAMICS FOR AEROELASTIC ANALYSES OF INTERFERING SURFACES, PART 1

April 1971 92 p refs Held at Tonsberg, Norway, 3-4 Nov. 1970

(AGARD-CP-80-71) Avail NTIS

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1 SOME CONSIDERATIONS RELATIVE TO THE PREDICTION OF UNSTEADY AIR LOADS ON INTERFERING SURFACES H Ashley (Stanford Univ) 22 p refs (See N71-29334 17-01)

2 CALCULATION METHODS FOR UNSTEADY AIRFORCES OF TANDEM SURFACES AND T-TAILS IN SUBSONIC FLOW D E Davis (Royal Aircraft Estab Farnborough, England) 22 p refs (See N71-29335 17-01)

3 REPRESENTATION OF A WING IN THE LIFTING LINE, APPLICATION OF THE INTERACTION CALCULATIONS OF TWO WINGS IN TANDEM R Dat and Y Akamatsu (Office Natl D'Etudes et de Recherches Aerospatiales, Paris, France) 17 p refs (See N71-29336 17-01)

4 A SUPERSONIC BOX COLLOCATION METHOD FOR THE CALCULATION OF UNSTEADY AIRFORCES OF TANDEM SURFACES D L Woodcock and E J York (Royal Aircraft Estab., Farnborough, England) 26 p refs (See N71-29337 17-01)

N71-29334# Stanford Univ., Calif

SOME CONSIDERATIONS RELATIVE TO THE PREDICTION OF UNSTEADY AIR LOADS ON INTERFERING SURFACES

H Ashley *In* AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 1 Apr 1971 22 p refs (See N71-29333 17-01)

Avail NTIS

Loading singularities inherent in linearized potential theory are classified as local, in the sense that both the nature and magnitude of the singularity are determined by boundary conditions in the inner field, or global, in the sense that the entire boundary value problem must be solved to determine their details Available results are reviewed relative to discontinuities in surface slope, planform shape, dihedral angle, etc and suggestions are offered for combining them into numerical solution schemes With respect to the analysis of interfering lifting surfaces, selected recent activity in the United States on continuous solution of various subsonic and supersonic cases is described Regarding the area-element or box approach to the latter, it is recommended that an element in the form of a trapezium, similar to that employed by Woodward for steady flow, will also improve the behavior of predicted loads for oscillatory motion of interacting surfaces Formulas for certain of the required influence coefficients are developed Some nonlinear effects are examined which are felt to have greater significance for interference problems than for isolated lifting wings The phenomena include the normal displacement and self-deformation of wakes which induce loads on aft surfaces, the local influences of profile thickness and displacement due to boundary layer growth Author

N71-29335# Royal Aircraft Establishment Farnborough (England)

CALCULATION METHODS FOR UNSTEADY AIRFORCES OF TANDEM SURFACES AND T TAILS IN SUBSONIC FLOW

D E Davis *In* AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces Part 1 Apr 1971 22 p refs (See N71-29333 17-01)

Avail NTIS

The basis of numerical methods, using continuous distributions of loading, for evaluating oscillatory generalised airforce coefficients for interfering and intersecting surfaces inclined everywhere at small angles to a subsonic mainstream flow is described. Particular application to tandem surfaces and T-tails is discussed briefly. Author

N71-29336# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

REPRESENTATION OF A WING IN THE LIFTING LINE: APPLICATION OF THE INTERACTION CALCULATIONS OF TWO WINGS IN TANDEM [REPRESENTATION D'UNE AILE PAR DES LIGNES PORTANTES; APPLICATION AU CALCUL DE L'INTERACTION DE DEUX AILES EN TANDEM]

R Dat and Y Akamatsu *In* AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 1 Apr 1971 17 p refs In FRENCH, ENGLISH summary (See N71-29333 17-01)

Avail NTIS

The simulation of wings by a lattice of lifting lines is summarized for the computation of unsteady aerodynamic forces on combinations including several lifting surfaces such as wing-horizontal tail or fin-horizontal tail. It can be considered as a compromise between the doublet lattice method which is advantageous for its flexibility, and the so called lifting surface method whose results are more accurate for a given number of collocation points. A numerical program was developed for the application to wings lying in two parallel planes. The particular features of the method of calculation are presented, as well as some numerical results. Author

N71-29337# Royal Aircraft Establishment, Farnborough (England)

A SUPERSONIC BOX COLLOCATION METHOD FOR THE CALCULATION OF UNSTEADY AIRFORCES OF TANDEM SURFACES

D L Woodcock and E J York *In* AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces Part 1 Apr 1971 26 p refs (See N71-29333 17-01)

Avail NTIS

A box collocation method is developed for the determination of the airforces on a pair of tandem surfaces (not necessarily coplanar) undergoing small oscillatory displacements in a supersonic flow. The perturbation velocity potential is evaluated at the vertices of a lattice of Mach lines on each wing. The results of the application of the method to a wing-tailplane configuration each of triangular planform are given. Author

N71-29338# Advisory Group for Aerospace Research and Development, Paris (France)

SYMPOSIUM ON UNSTEADY AERODYNAMICS FOR AEROELASTIC ANALYSES OF INTERFERING SURFACES, PART 2

Apr 1971 234 p refs Held at Tonsberg, Norway, 3-4 Nov 1970

(AGARD-CP-80-71) Avail NTIS

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N71-29339# Vereinigte Flugtechnische Werk-Fokker G m b H , Munich (West Germany)

SUBSONIC UNSTEADY AIRLOADS ON MULTIPLE LIFTING SURFACES

G Boehm and H Schmid *In* AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfacing, Part 2 Apr 1971 28 p refs (See N71-29338 17-01)

Avail NTIS

A survey is presented of the main features of lifting lattice methods and particularly of lifting surface methods. Ways to extend existing methods to arbitrary lifting surface configurations are also discussed. The following is a short description of these fundamentals and a detailed discussion of the numerical methods as established by the authors. Results obtained will be presented and compared with other theories. Author

N71-29340# Douglas Aircraft Co , Inc , Long Beach, Calif

NEW DEVELOPMENTS AND APPLICATIONS OF THE SUBSONIC DOUBLET-LATTICE METHOD FOR NONPLANAR CONFIGURATIONS

W P Rodden, J P Giesing, and T P Kalman *In* AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces Part 2 Apr 1971 28 p refs (See N71-29338 17-01)

Avail NTIS

Procedures for calculating the normalwash induced by a doublet line in nonplanar configurations and for calculating the interference between wings and bodies are given. Applications are

made to a non-coplanar wing-tail combination, a number of empennage configurations, a wing-fuselage and a wing-nacelle combination. Also considered is the calculation of velocity components in the flow field during oscillatory motion and the calculation of the distribution of induced drag in steady flow. Examples of both calculations are also presented. Author

N71-29341# Air Force Systems Command, Wright-Patterson AFB, Ohio. Flight Dynamics Lab.
APPLICATION OF AFFDL UNSTEADY LOAD PREDICTION METHOD TO INTERFERING SURFACES
W. J. Mykytow, J. J. Olsen and S. J. Pollock *In* AGARD Symp. on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr. 1971 24 p refs (See N71-29338 17-01)
Avail: NTIS

The results of engineering applications of subsonic and supersonic lifting surface methods to some of the AGARD configurations and other interesting configurations, are presented. The subsonic kernel function program is applied to several aspects of the wing-tail interaction problem. The subsonic double lattice method is also applied to the problem. Results are also presented for a supersonic Mach box program developed for T-tails and cruciform tails along with comparisons with piston theory. Comparison between the subsonic kernel function and the doublet lattice method is generally quite good. While the double lattice method usually required greater computing times for the same accuracy as the kernel function method, it has some advantages in its favor such as ease of application and extension to more complicated configurations. The supersonic results presented here appear to be of the proper order of magnitude when compared with piston theory; however, more applications and careful checking are indicated. Author

N71-29342# Royal Aircraft Establishment, Farnborough (England).
APPLICATIONS OF UNSTEADY AIRFORCE CALCULATION METHODS TO AGARD INTERFERENCE CONFIGURATIONS
D. E. Davies *In* AGARD Symp. on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr. 1971 18 p (See N71-29338 17-01)
Avail: NTIS

Calculations of generalised airforce coefficients were carried out for the configurations of wing and horizontal tail and of fin and horizontal tail oscillating in subsonic flow in prescribed modes at given frequencies. Author

N71-29343# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
MEASUREMENT OF UNSTEADY AIR LOADS OF INTERACTION BETWEEN LIFTING SURFACES IN TANDEM [MESURES DES FORCES INSTATIONNAIRES D'INTERACTION ENTRE SURFACES PORTANTES EN TANDEM]
A. Destuynder *In* AGARD Symp. on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr. 1971 12 p refs In FRENCH; ENGLISH summary (See N71-29338 17-01)
Avail: NTIS

A series of wind tunnel tests were performed in view of analyzing the influence of several parameters on the aerodynamic interference between two lifting surfaces in tandem. The aim was to determine the magnitude of the coupling terms in order to provide a theoretical explanation of the flutter instabilities occurring on variable sweep airplanes. The tests were limited to two types of motion: pure translation and pure pitching oscillation of one wing. The model consisted of two rectangular or swept wings whose relative position could be adjusted continuously in the horizontal as well as in the vertical direction. Some comparisons between theory and experiment are given. Author

N71-29344# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Munich (West Germany).
T-TAIL AEROELASTIC ANALYSIS FOR FOKKER F.28
J. Ylf and R. J. Zwaan (Natl. Aero and Astronautical Res. Inst.) *In* AGARD Symp. on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr. 1971 15 p refs (See N71-29338 17-01)
Avail: NTIS

Data from an aeroelastic and flutter analysis are presented. The data include lateral gust loading, aircraft designs, and mission analysis. The results indicate that mass balancing of the rudder and aileron may be deleted, testing time for high speed flutter may be reduced, and the risks of extensive modifications to the design may be reduced. The tests also achieved the certification of the aircraft. E.H.W.

N71-29345# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
SOME RECENT INVESTIGATIONS ON FLUTTER IN SUBSONIC FLOW, CAUSED BY INTERFERENCE AERODYNAMIC FORCES BETWEEN WING AND TAIL OF A VARIABLE GEOMETRY AIRCRAFT
W. Seidel and O. Sensburg *In* AGARD Symp. on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr. 1971 10 p refs (See N71-29338 17-01)
Avail: NTIS

A method for routine flutter calculations utilizing interference aerodynamic forces between wing and tail is presented. The elastomechanic system of the aircraft is described by branch modes and the airforces for these branch modes are produced by superimposing air forces for arbitrary polynomials. The air forces are calculated for a distinct vertical offset between wing and tail with the exact kernel functions. A large variety of stiffness parameter variations was performed such as wing stiffness, fuselage stiffness and tailplane connection stiffness in order to get a better understanding of the flutter phenomenon involved and to find a cure for solving the problem. Some of the results are compared with results from wind tunnel model tests to establish the validity of the analytical method used. Author

N71-29346# National Aero- and Astronautical Research Inst., Amsterdam (Netherlands).
UNSTEADY AERODYNAMICS FOR WINGS WITH CONTROL SURFACES
H. Tijdeman and R. J. Zwaan *In* AGARD Symp. on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr. 1971 15 p refs (See N71-29338 17-01)
Avail: NTIS

A kernel function method to calculate pressure distributions over wings with harmonically oscillating control surfaces in subsonic flow is briefly discussed. Comparisons of calculated and measured pressure distributions are given for different planforms. Mach numbers and reduced frequencies. An analysis is given of pressure distributions measured at high subsonic and transonic Mach numbers. Author

N71-29347# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
APPLICATION OF LIFTING SURFACE THEORY TO WINGS PROVIDED WITH CONTROL SURFACES [APPLICATION DE LA THEORIE DE LA SURFACE PORTANTE A DES AILES MUNIES DE GOUVERNES]
B. Darras and R. Dat *In* AGARD Symp. on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces, Part 2 Apr. 1971 14 p refs In FRENCH; ENGLISH summary (See N71-29338 17-01)
Avail: NTIS

A method for solving the problem of control surfaces in subsonic unsteady flow is considered. It is based on the explicitation of the logarithmic singularity of the pressure field and on an analysis

of the usual matrix solution of the integral equation This method, whose application to a rectangular wing has already been described, is extended here to an arbitrary planform The comparison of experimental and theoretical results obtained for the rectangular wing is also shown. Author

N71-29348# British Aircraft Corp., Warton (England)
UNSTEADY AIRFORCES FOR WINGS WITH CONTROL SURFACES. PART 1: LOADING FUNCTIONS
B. L. Hewitt *In* AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 2 Apr 1971 26 p refs (See N71-29338 17-01)
Avail NTIS

An attempt was made, through the use of matched asymptotic expansion techniques, to define methods for finding the inner singular pressure loading functions associated with a wide variety of interaction effects on wings with unbalanced control surfaces The work is basic in that it facilitates the construction of adequate loading forms which are necessary before attempting to obtain convergent lifting surface theory solutions. It extends the practical scope of Landahl's work and gives, as a result, sound reasons for modifying the loading recipes Author

N71-29349# British Aircraft Corp., Warton (England)
UNSTEADY AIRFORCES FOR WINGS WITH CONTROL SURFACES. PART 2: CALCULATION METHODS
B. L. Hewitt *In* AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 2 Apr 1971 24 p refs (See N71-29338 17-01)
Avail NTIS

Using the local loading solutions, a numerical method is described which accurately evaluates the associated discontinuous downwash distribution, w(2) for steady flow W(2) is then regularised through the specified boundary conditions to give w(1) which can then be used to gain converged solutions for the residual loading Full loading solutions are found for rectangular wing with control surface configurations in incompressible flow, and the results compared with other methods The form of w(1) is calculated on a simple swept wing with control surface configuration, and is found to become irregular near the hinge line corners Modifications to the originally chosen special loading form are suggested which should lead to convergent loading solutions for swept wings Author

N71-29350# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)
PRESSURE MEASUREMENTS ON AN HARMONICALLY OSCILLATING SWEPT WING WITH TWO CONTROL SURFACES IN INCOMPRESSIBLE FLOW
H. Forsching, H. Triebstein, and J. Wagener *In* AGARD Symp on Unsteady Aerodynamics for Aeroelastic Analyses of Interfering Surfaces. Part 2 Apr 1971 15 p refs (See N71-29338 17-01)
Avail NTIS

The results of an experimental study of the pressure singularities occurring along the control surface edges of a harmonically oscillating swept wing control surface system in incompressible flow are presented and discussed The two control surfaces ranged along the whole span of the wing and could be excited so that alternatively the inner or the outer flap or even both were oscillating with different phases and amplitudes relative to each other and relative to the wing Author

N71-31459# Advisory Group for Aerospace Research and Development Paris (France)
TECHNICAL EVALUATION REPORT ON AGARD SPECIALISTS' MEETING ON AERODYNAMIC INTERFERENCE
David J. Peake May 1971 18 p refs Conf held at Silver Spring, Md., 28-30 Nov 1970
(AGARD-AR-34-71) Avail NTIS

A critique of topics discussed at the AGARD meeting on aerodynamic interference is presented Discussions evaluated include wing-body and wing-body-tail interference, airframe-propulsion interactions, and airframes-stores interference The major advance is considered to be the treatment of a lifting wing-body combination in which a sheet of trailing vorticity from a wing was coupled with the finite element method It is recommended that a calibration model of a wing-body combination be chosen for checking various computation schemes and some high Reynolds number wind tunnel tests be conducted to provide details of the junction pressure distributions and the three-dimensional boundary layers and wakes F O S

N71-35198# Advisory Group for Aerospace Research and Development, Paris (France). Structures and Materials Panel
A COMPARISON OF METHODS USED IN LIFTING SURFACE THEORY
D. L. Woodcock (RAE, Farnborough, Engl.) Jun. 1971 149 p refs Supplement to the Manual on Aeroelasticity, Part 6; see N65-24758
(AGARD-R-583-71) Avail NTIS

A joint research project, organized by the AGARD Structures and Materials Panel is reported The purpose of the project is to establish the relative merits of different methods of calculating the air forces on oscillating wings, and to provide a standard which can be used in the future for comparison or test purposes A scheme of cases to be considered was set up which covered variations of the parameters, planform geometry, mach number reduced frequency and mode of oscillation Contributions came from six countries using nearly thirty different methods and comprising nearly eight hundred calculations The tabulated results are preceded by descriptions of the various methods used and by a comprehensive system of annotation Author

N71-36400# Advisory Group for Aerospace Research and Development, Paris (France) Ad Hoc Committee
ENGINE-AIRPLANE INTERFERENCE AND WALL CORRECTIONS IN TRANSONIC WIND TUNNEL TESTS
Aug. 1971 143 p refs
(AGARD-AR-36-71) Avail. NTIS

CONTENTS:

N71-36401# Advisory Group for Aerospace Research and Development, Paris (France)
CONCLUSIONS AND RECOMMENDATIONS ON ENGINE AIRPLANE INTERFERENCE AND WALL CORRECTIONS IN TRANSONIC WIND TUNNEL TESTS
Antonio Ferri (New York Univ., N. Y.) *In its* Eng.-Airplane Interference and Wall Corrections in Transonic Wind Tunnel Tests Aug 1971 5 p (See N71-36400 23-01)
Avail NTIS

The conclusions and recommendations are presented concerning the correct representation in wind tunnel tests of the interaction between engine flow and airplane characteristics, and wall interference at high lift A review of experimental methods in use for determining engine-airplane interference in transonic tests includes the following topics (1) inlet airplane interference, (2) engine thrust with airplane drag and nozzle characteristics, (3) exhaust flow and airplane interference, and (4) determination of interference of the engine flow on the aerodynamic

characteristics of the complete configuration. It is concluded that all of the approaches have important unknowns and shortcomings; action is required by research groups to develop new techniques, and improve existing ones. F.O.S.

N71-36402# Advisory Group for Aerospace Research and Development, Paris (France).

ENGINE-AIRPLANE INTERFERENCE IN TRANSONIC TESTS

F. Jaarsma (Natl. Aero- and Astronaut. Res. Inst.) *In its* Eng. Airplane Interference and Wall Corrections in Transonic Wind Tunnel Tests Aug. 1971 117 p refs (See N71-36400 23-01)

Avail: NTIS

A compilation is presented of the response to a distributed questionnaire on engine-airframe interference in transonic tests among aeronautical laboratories operating transonic wind tunnels, aircraft manufacturers, engine companies, and airplane users in the AGARD countries. The experimental techniques, correction procedures, advantages and limitations of inlet, nozzle/afterbody, complete model testing, and engine thrust determination are discussed in a technical order. Author

N71-36403# Advisory Group for Aerospace Research and Development, Paris (France).

WALL CORRECTIONS FOR AIRPLANES WITH LIFT IN TRANSONIC WIND TUNNEL TESTS

R. Monti (Univ. Degli Studi, Naples, Italy) *In its* Eng.-Airplane Interference and Wall Corrections in Transonic Wind Tunnel Tests Aug. 1971 15 p refs (See N71-36400 23-01)

Avail: NTIS

The technical information supplied by the Ad Hoc Committee is summarized. After some preliminary remarks on wall interference corrections in transonic tests, the different answers to the AGARD questionnaire are presented together with the main points made by the committee members as representatives of the different countries. A number of general agreements among the committee members are stated which indicate the state-of-the-art of transonic wind tunnel corrections. The discussions and the conclusions of the committee are presented on the problems which appear to be most important for future research. Problems are briefly reviewed and research areas are indicated for which the committee agreed an international program will be most profitable. A list of references is provided which includes the works referenced by all the different groups participating in the committee. Author

N72-11854# Advisory Group for Aerospace Research and Development, Paris (France)

FACILITIES AND TECHNIQUES FOR AERODYNAMIC TESTING AT TRANSONIC SPEEDS AND HIGH REYNOLDS NUMBER

Aug 1971 409 p refs Presented at the Fluid Dyn Panel Specialists Meeting, Goettingen, 26-28 Apr 1971

(AGARD-CP-83-71) Avail NTIS HC $6.00/MF $0.95

Theoretical methods and wind tunnel facilities for transonic aerodynamic testing of aircraft at high Reynolds numbers are outlined. Requirements of test facilities are clarified and possible improvements in existing facilities and testing techniques are discussed. For individual titles, see N72-11855 through N72-11887

N72-11855# Royal Aircraft Establishment, Farnborough (England)

SCALE EFFECTS IN FLOWS OVER SWEPT WINGS

M G Hall *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 22 p refs (See N72-11854 03-01)

Avail NTIS HC $6.00/MF $0.95

A review is given of the effects of variations in Reynolds number on the possible types of flow over a swept wing and the boundaries between them. Three main flow regimes are discussed in turn: the attached boundary layer which may be laminar or turbulent and where the position of transition is important, the thin wake which extends downstream from the trailing edge of the wing, and the regime of separated flow. Their interactions with the external flow and with each other are included. The flow structures are three dimensional in general. Reynolds number effects are best understood where simple extensions from two dimensions can be made. The most serious gaps in understanding are found where compressibility and strong interactions are important. Author

N72-11856# Royal Aircraft Establishment, Bedford (England)

SOME ASPECTS OF VISCOUS INVISCID INTERACTIONS AT TRANSONIC SPEEDS, AND THEIR DEPENDENCE ON REYNOLDS NUMBER

J E Green *In* AGARD Facilities and Tech. for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug. 1971 12 p refs (See N72-11854 03-01)

Avail NTIS HC $6.00/MF $0.95

Current understanding of viscous-inviscid interactions is reviewed, with particular reference given to the characteristics of interactions on transonic swept wings and their dependence upon Reynolds number. Interactions of three different degrees are discussed: the weak interaction between boundary layer and wake development overall and the flow field at large, the strong but localized interaction beneath shockwaves and at trailing edges in fully attached flow; and the strong interactions which involve boundary layer separation and hence have an important effect on the entire flow field. Finally, the possibilities are discussed of manipulating the boundary layer in order to simulate, in the wind tunnel, the viscous-inviscid interactions found at flight Reynolds numbers. Author

N72-11857# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany)

A METHOD FOR CALCULATING THE TRANSONIC BUFFET BOUNDARY INCLUDING THE INFLUENCE OF REYNOLDS NUMBER

F Thomas and G Redeker *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 14 p refs (See N72-11854 03-01)

Avail NTIS HC $6.00/MF $0.95

A purely theoretical method for calculating the buffet boundary of straight and swept wings including the effects of Reynolds numbers is reported. In the procedure of calculation, Sinnott's method for estimating the pressure distribution in a transonic flow with shock waves is used, as well as the methods of Walz and Cumpsty and Head for calculating turbulent boundary layers in two- and three-dimensional compressible flow. The agreement of the theoretical calculation with experimental results from wind tunnel and flight tests at various Reynolds numbers is very satisfactory. Author

N72-11858# Royal Aircraft Establishment, Farnborough (England) Aerodynamics Dept

A TYPE OF STALL WITH LEADING EDGE TRANSONIC FLOW AND REAR SEPARATION

J Osborne and H H Pearcey *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 11 p refs (See N72-11854 03-01)

Avail NTIS HC $6.00/MF $0.95

Surface pressure measurements are presented for a leading edge, transonic flow which occurs for high angles of incidence and for stream speeds in the medium subsonic range. A shock induced separation develops in the first 5% of the chord, and also present is the rear separation that would be expected in the low speed stall of an aerofoil having a thickness/chord ratio/greater than about 10%. Results for transition fixed and free reproduce respectively the classical features for turbulent and laminar-type interactions at the leading edge shock; these leave different disturbances in the reattached turbulent layer which then react differently on the rear separation. A few results are included for an intermediate effect on transition. The Reynolds number for all the tests was in the region of 2 x 1 million based on aerofoil chord Author

N72-11859*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va

REYNOLDS NUMBER REQUIREMENTS FOR VALID TESTING AT TRANSONIC SPEEDS

William B Igoe and Donald B Baals *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 5 p refs (See N72-11854 03-01)

(NASA-TM-X-67412) Avail NTIS HC $6.00/MF $0.95 CSCL 20D

The variation of wing shock location with Reynolds number has been examined for configurations for which both flight and wind tunnel wing pressure distribution data were available to determine if there is a minimum level of Reynolds numbers, short of full scale, at which reliable flow simulation can be achieved in transonic test facilities. The shock locations as a function of Reynolds numbers at conditions of constant Mach number and angle of attack were normalized so that shock position was obtained in relative terms from zero to unity for each configuration and condition studied. Normalizing the shock location permitted the comparison of data for different configurations and conditions on a common basis. Not enough data have been analyzed thus far to obtain conclusive results

Author

N72-11860# Northrop Corp., Hawthorne, Calif Aircraft Div

RECENT EXPERIENCE IN THE TRANSONIC TESTING OF TWO DIMENSIONAL SWEPT AND STRAIGHT WINGS WITH HIGH LIFT DEVICES

W E Grahame, J W Headley, and L W Rogers *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 17 p refs (See N72-11854 03-01)

Avail NTIS HC $6.00/MF $0.95

The results of a series of transonic tests of two dimensional wings with various high lift devices are presented. The tests were performed in an aerodynamic transonic wind tunnel on an unswept wing with a jet flap and a swept wing with boundary control devices. Both wings were tested through a Mach range of M = 0.70 to M = 0.95 and a Reynolds Numbers range of 2.5 to 6.5 million per foot. Additional tests included a supercritical wing with slot blowing and a leading edge flap with a jet flap. Comparisons of wing pressure distributions and flow visualization studies illustrate the effectiveness of the jet flap and also the high lift devices in controlling flow separation. Longitudinal characteristics which show the effects of Reynolds number are also presented. Comparative analyses indicating the improvement obtained with each of the high lift devices is shown Author

N72-11861# National Aeronautical Establishment, Ottawa (Ontario)

THE TRANSONIC PERFORMANCE OF TWO DIMENSIONAL JET FLAPPED AEROFOILS AT HIGH REYNOLDS NUMBERS

D J Peake, H Yoshihara, D Zonars, and W Carter *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 39 p refs (See N72-11854 03-01)

Avail NTIS HC $6.00/MF $0.95

Tests in the NA transonic wind tunnel were conducted to determine the effect of Reynolds numbers on the transonic performance of a 10% aft cambered profile with jet flaps - in particular the effect on the pressure distribution, drag divergence, and buffet onset. Distributed suction was applied on the sidewalls in the vicinity of the model to insure that the interaction of the shock was primarily with the airfoil boundary layer. The absence of sidewall suction had a significant effect upon the upper surface flow, with the shock being displaced upstream by about 15% of the chord. In the range of the Reynolds number tested, there was a noticeable effect of Reynolds number on drag divergence and a significant effect on buffet onset Author

N72-11862# Deutsche Forschungs und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)

EXPERIMENTAL INVESTIGATION OF THE DRAG OF WINGS WITH A BLUNT TRAILING EDGE AT TRANSONIC SPEEDS

M Tanner *In* AGARD Facilities and Tech for Aerodyn. Testing at Transonic Speeds and High Reynolds Number Aug 1971 6 p refs (See N72-11854 03-01)

Avail NTIS HC $6.00/MF $0.95

The possible improvement of aerodynamic profiles due to blunt trailing edges, drag and lift measurements was studied on two wings of finite span in a transonic wind tunnel. The Mach number had values from 0.5 to 2.2 and the Reynolds number was about R = 1,500,000. From these results it was possible to conclude that in order to achieve a drag reduction at transonic speeds the trailing edge thickness should not be excessive and the boattailing angle should be small. Furthermore, a special broken shape of the trailing edge is favorable for low drag at these Mach numbers. At supersonic speeds the attainable drag reduction at zero lift is greater than predicted by Chapman. The lift curve slope is greater for the wing with a blunt trailing edge than for the wing with a conventional sharp trailing edge. With the most efficient blunt trailing edge the maximum lift to drag ratio at transonic speeds is only a few per cent lower than for the wing with a sharp trailing edge Author

N72-11863# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)

FORCE AND PRESSURE MEASUREMENTS ON A SLENDER DELTA WING AT TRANSONIC SPEEDS AND VARYING REYNOLDS NUMBERS

W Stahl, K Hartmann, and W Schneider *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 11 p refs (See N72-11854 03-01)

Avail NTIS HC $6.00/MF $0.95

Transonic wind tunnel investigations were carried out on a slender delta wing with aspect ratio A = 0.52 at Mach numbers 0.5, 0.7, 0.8, 0.9, 0.95, 0.975, 1.0, 1.1, and 1.2 for angles of incidence up to about 30 deg. Normal force and pitching moments were measured, as well as spanwise pressure distributions on the wing's pressure and suction side at five cross sections. The Reynolds number was held constant at a value of Re = 2,700,000 for all Mach numbers. The normal force and pitching moment coefficients showed a noticeable dependence on Reynolds number, the pressure distribution was influenced mainly around the suction peak. Successful attempts were made at low Reynolds number to influence the boundary layer on the wing's suction side by means of a carborundum band. Insight was obtained into the structure of the flow field, near sonic velocities, by using a newly developed smoke visualization technique and with the help of oil flow pictures

Author

N72-11864# Army Missile Command, Huntsville, Ala

BODIES OF REVOLUTION AT TRANSONIC SPEEDS: THE ESTIMATION OF REYNOLDS NUMBER EFFECTS

T H Moulden, D J Spring, R O Saisi, K Aoyama, and J M Wu *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 13 p refs (See N72-11854 03-01)

Avail NTIS HC $6.00/MF $0.95

The experimental data presented are taken from a series of tests on a body of revolution at transonic speeds. The test Reynolds number was of the order of one million. Both mounting strut and tunnel wall interference effects are discussed. A theoretical procedure is developed to take account of the viscous effects on the body. It is shown that the potential flow theory of Wu and Aoyama gives close agreement with experimental data. However, and particularly to study separation and Reynolds number effects it is necessary to introduce boundary layer effects in the theoretical work. Taking the displacement surface as an equivalent body for the second approximation it is shown that only a small change in surface pressure distribution on the body is realized. Hence, it follows that in the absence of separation a large change in Reynolds number is of little

significance as far as surface pressures are concerned The general conclusion is that for a body of revolution, tunnel and mounting interference effects are more significant than Reynolds number effects, provided the flow is not separated Author

N72-11865# Grumman Aerospace Corp., Bethpage, N.Y.
TRANSONIC AERODYNAMIC CHARACTERISTICS AND THEIR EVALUATION
Arthur A. Lambert *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 4 p refs (See N72-11854 03-01)
Avail NTIS HC $6.00/MF $0.95

The need for more systematic transonic wind tunnel testing to pin down the effects of flow and environment combinations and to establish a more scientific basis for flight simulation and analysis is outlined The discussion includes the effects of steady, unsteady, and mixed flow phenomena on tools used for design and evaluation of the important transonic flight performance parameters of modern aircraft i.e., max g capability, maneuvering buffet, level flight buffet, control problems, and peak drag characteristics The design tools include trailing edge angle criteria, the effect of various sweep lines and wing leading edge development Wind tunnel evaluation tools include isobar contours, pressure taps, accelerometers, tuft stands, and oil flow techniques The effects of scale and Reynolds Number in connection with various flow phenomena and associated flight conditions are also discussed Author

N72-11866# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
TRANSONIC TESTING OF THE ENGINE NACELLE AIR INTAKE AND AFTERBODY [ENTREE D'AIR ET ARRIERE CORPS DE FUSEAU MOTEUR EN TRANSSONIQUE]
J. Leynaert *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 10 p refs In FRENCH, ENGLISH summary (See N72-11854 03-01)
Avail NTIS HC $6.00/MF $0.95

An example is presented of the study of a double-flux engine nacelle at high subsonic Mach numbers, the investigation being made at high Reynolds numbers with two separate models for the air intake and the afterbody The test on the afterbody shows that the conditions of variable jets do not react significantly on the upstream flow around the nacelle intake and cowl, apart from the immediate vicinity of the exhaust, this fact justifies the large scale, study of the air intake with a model supported downstream by a cylindrical tube replacing the jet In the same way, mass-flow rate variations of the air intake do not react on the flow around the afterbody, in a given margin, this allows the study of the afterbody on an upstream sting Author

N72-11867# Aircraft Research Association, Ltd., Bedford (England)
POSSIBILITIES FOR SCALE EFFECT ON SWEPT WINGS AT HIGH SUBSONIC SPEEDS: RECENT EVIDENCE FROM PRESSURE PLOTTING TESTS
A. B. Haines *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 11 p refs (See N72-11854 03-01)
Avail NTIS HC $6.00/MF $0.95

The possibilities for scale effect on swept wings under supercritical flow conditions at high subsonic speeds are discussed on the basis of evidence from pressure plotting tests on a variety of wings For the Super VC 10, comparison of pressure distributions measured in flight, and in model tests at R = 5.4 x 1 million shows some scale effect For other designs however, the scale effect could be much greater, the paper shows that the underfixing technique has limitations when applied to a sweptback wing Examples are included where the flow patterns are very complex with many interacting features, in such cases, it is often difficult even to forecast whether the scale effect is favourable or unfavourable Further improvements in swept wing design will increase the likelihood of serious scale effect Author

N72-11868# Aeronautical Research Inst. of Sweden, Stockholm
CORRELATION OF SOME TRANSONIC WIND TUNNEL TEST DATA TO FLIGHT TEST RESULTS FOR TWO SLENDER WING AIRPLANES
Sven Erik Nyberg *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 10 p (See N72-11854 03-01)
Avail NTIS HC $6.00/MF $0.95

Some of the flight test data obtained on two slender wing airplanes have been correlated to transonic wind tunnel test data obtained with 1/30 and 1/50 scale models Static stability and control derivatives as well as damping and period in pitch and dutch roll oscillations as predicted by the wind tunnel tests show good agreement with flight tests The predicted zero lift drag for one of the airplanes was higher than the flight test drag whereas the agreement in lift induced drag was satisfactory Predicted component loadings have been found to agree well with flight test results Air inlet pressure recovery was slightly higher in flight than in the wind tunnel Flow distortion at engine face shows good correlation even at high angles of attack It is concluded from these results, that for slender wing configuration, transonic wind tunnel test data are in general reliable, even if obtained at relatively low Reynolds number Author

N72-11869*# National Aeronautics and Space Administration Flight Research Center, Edwards, Calif.
A COMPARISON OF SOME AERODYNAMIC DRAG FACTORS AS DETERMINED IN FULL SCALE FLIGHT WITH WIND-TUNNEL AND THEORETICAL RESULTS
Edwin J. Saltzman and Donald R. Bellman *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 22 p refs (See N72-11854 03-01)
(NASA-TM-X-67413) Avail NTIS HC $6.00/MF $0.95 CSCL 20D

Reliable techniques for defining flight values of overall aircraft drag and turbulent skin friction, and the drag associated with local regions of separated flow are reported Selected results from these studies are presented for several types of aircraft, including the X-15, the XB-70, lifting bodies, and military interceptors These flight results are compared with predictions derived from windtunnel models or, for friction, with the Karman-Schoenherr relationship The flight experiments have defined the turbulent skin friction to Reynolds numbers somewhat above 10 to the 8th power the overall drag of two airplanes, base pressure coefficients for aircraft and for an aft-facing step immersed in a thick boundary layer A flight application of a splitter plate for reducing base drag is discussed along with examples of the drag associated with afterbody flow separation for shapes having relatively large afterbody closure angles Author

N72-11870*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.
FEASIBILITY OF TESTING A LARGE-CHORD, SWEPT-PANEL MODEL TO DETERMINE WING SHOCK LOCATION AT FLIGHT REYNOLDS NUMBER
Jones F. Cahill (Lockheed-Georgia Co.), Stuart L. Treon, and William R. Hofstetter *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 11 p refs (See N72-11854 03-01)
(Contracts F33615-69-C-01256, F33615-67-C-1777)
(NASA-TM-X-67414) Avail NTIS HC $6.00/MF $0.95 CSCL 20D

As a part of a study of methods for simulating high Reynolds number aerodynamic characteristics of large aircraft, tests have been conducted in an 11 foot transonic wind tunnel to determine the feasibility of using a large chord wind panel model to investigate the variation of shock location with Reynolds number The model was untwisted and was of constant chord and thickness The airfoil section was that from one station on the span of a high speed transport airplane for which a substantial amount of flight and wind tunnel pressure distribution data had previously been obtained at widely different Reynolds numbers with indications of a large scale effect on

shock location The major findings from this study were that the variation of shock location on the panel model was identical in character, but considerably smaller over the Reynolds number range from 8.8 million to 28.0 million than that indicated by existing data on the complete wing Generally, the panel model data on shock location and trailing-edge pressure recovery tended toward better agreement with flight data than with previous wind tunnel data on smaller complete models Author

N72-11871# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
WIND TUNNEL QUALIFICATION BY PERFORMANCE PREDICTION AND FLIGHT VERIFICATION [VALIDITE DE LA SOUFFLERIE POUR LA PREVISION DES PERFORMANCES ET DES QUALITES DE VOL]
Ph Poisson-Quinton *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 16 p refs In FRENCH (See N72-11854 03-01)
Avail NTIS HC $6 00/MF $0 95
Summaries of brief data sheets are presented that contain information on new analytical prediction methods and flight tests for the development of transonic wind tunnels Points of agreement as well as of disagreement are illustrated to stimulate new research for improving wind tunnel qualities Author

N72-11872*# National Aeronautics and Space Administration Ames Research Center Moffett Field Calif
TRANSONIC TESTING IN EXISTING WIND TUNNELS
J Lloyd Jones *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 8 p refs (See N72-11854 03-01)
(NASA-TM-X-67415) Avail NTIS HC $6 00/MF $0.95 CSCL 14B
The problems of obtaining representative transonic aerodynamic data in existing wind tunnels are examined The problems are approached by reviewing those factors which influence the accuracy of measurement and flow simulation Examples of flow simulation anomalies are given Demands for increased accuracy and requirements for conducting transonic investigations under conditions increasingly more susceptible to simulation anomalies are cited Author

N72-11873# Lockheed-Georgia Co , Marietta
SIMULATION OF FULL SCALE FLIGHT AERODYNAMIC CHARACTERISTICS BY TESTS IN EXISTING TRANSONIC WIND TUNNELS
Jones F Cahill *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 8 p refs (See N72-11854 03-01)
Avail NTIS HC $6 00/MF $0 95
Although newly evolving concepts will enable the construction of relatively inexpensive wind tunnels capable of producing transonic aerodynamic data at flight Reynolds numbers, a substantial portion of future aircraft development testing will be done at subscale conditions It is imperative, therefore, that methods be developed for accurate simulation of flight aerodynamic characteristics during tests at low Reynolds numbers Several concepts for high Reynolds number simulation have been advanced, and some have been demonstrated for isolated cases Some of these concepts are reviewed in the light of existing data Author

N72-11874# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)
SIMULATION OF TWO DIMENSIONAL AEROFOIL FLOW AT HIGH SUBSONIC MACH NUMBERS AND HIGH REYNOLDS NUMBERS BY MEANS OF AN EQUIVALENT BODY OF REVOLUTION
W Lorenz-Meyer *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 9 p refs (See N72-11854 03-01)
Avail NTIS HC $6.00/MF $0 95
In order to study the effect of high Reynolds numbers on the transonic flow past two-dimensional aerofoils, an equivalent body of revolution was constructed, having a four to five times larger chord size than the corresponding aerofoil, and giving the same rate of tunnel blockage The contour of the body was calculated by means of a source-sink distribution Force and pressure measurements have been performed in a transonic tunnel at Mach numbers from 0.5 to 0.925 and Reynolds numbers from Re sub l = 4 million to 16 million In the subcritical range the results show good agreement with the calculated first-order potential flow The evaluation of minimum pressure coefficient and shock position show that from Re sub L = 8 million no significant dependence on Reynolds number exists either at subcritical or supercritical speeds. Author

N72-11875# Hawker Siddeley Aviation. Ltd., Kingston upon Thames (England)
ON THE POSSIBILITY OF DEDUCING HIGH REYNOLDS NUMBER CHARACTERISTICS USING BOUNDARY LAYER SUCTION
Cliff L Bore *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 10 p refs (See N72-11854 03-01)
Avail NTIS HC $6 00/MF $0 95
It seems that the most crucial differences of characteristics from wind tunnel models to full scale aircraft stem from the fact that the boundary layers on the model are usually relatively too thick Consequently it has been suggested that full-scale behaviour may be more accurately simulated if the thickness of the boundary were reduced appropriately by means of suction through porous strips in the surface of the models A suitable technique would afford convenient means for varying the boundary layer thickness without stopping the wind tunnel and should be applicable to more model configurations than conventional underfixing of transition The implications of these propositions are examined in the light of boundary layer calculations and data Author

N72-11876# London Univ (England)
SOUND FIELDS GENERATED BY TRANSONIC FLOWS OVER SURFACES HAVING CIRCULAR PERFORATIONS
M M Freestone and R N Cox *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 8 p refs (See N72-11854 03-01)
Avail NTIS HC $6 00/MF $0 95
Tests made on the sound waves radiated from perforated transonic tunnel liners having perpendicularly drilled holes have shown that a regular pattern of coherent wave fronts occurs It is suggested that the coupling is caused by a disturbance propagating along the surface of the liner Results from individual holes indicate that the mechanism for production of sound waves is similar to that observed from two dimensional cavities, and that the Strouhal numbers of the modes occurring can be predicted with reasonable accuracy for both normal and inclined holes using a model proposed by Rossiter Author

N72-11877# New York Univ , N Y
ENGINE AIRPLANE INTERFERENCE AND WALL CORRECTIONS IN TRANSONIC WIND TUNNEL TESTS
Antonio Ferri *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 6 p (See N72-11854 03-01)
Avail NTIS HC $6 00/MF $0 95
Recent developments of high performance airplanes have generated requirements for the prediction of the aerodynamic performance of airplane designs with extremely high accuracy A critical review of present experimental methods led to the initiation of two separate efforts related to experiments in transonic flows (1) determination of Reynolds number effects

and the design of high Reynolds number wind tunnels, and (2) correct representation in wind tunnel tests of the interaction between engine flow and airplane characteristics, and wall interference at high lift. Author

N72-11878*# National Aeronautics and Space Administration Langley Research Center, Langley Station, Va

TRANSONIC FREE-FLIGHT MODEL TESTING AT LARGE SCALE

Clarence L. Gillis *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 9 p refs (See N72-11854 03-01)

(NASA-TM-X-67416) Avail NTIS HC $6.00/MF $0.95 CSCL 20D

The use of free flight models for transonic testing at high Reynolds numbers is discussed. Several specific examples of experimental investigations are briefly reviewed to illustrate the scope of research that can be conducted by utilizing the advantages of free flight models. These advantages are primarily the lack of interference or constraints imposed by test facilities and model support systems and the dynamic freedom possessed by free flight models. High Reynolds numbers are obtained by using large models flown at relatively low altitudes. It is shown that models 10 meters or more in length will be required for research at Reynolds numbers sufficiently high to provide representative simulation of flow conditions for large modern aircraft. Several methods for launching models of this size are discussed. These methods include free drops from airplanes or balloons and ground launches with the use of internal or external rocket motors. All the launching methods discussed have been successfully demonstrated on flight vehicles of the size and weight required to attain the necessary test conditions. Author

N72-11879*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif

ON THE USE OF FREON-12 FOR INCREASING REYNOLDS NUMBER IN WIND-TUNNEL TESTING OF THREE DIMENSIONAL AIRCRAFT MODELS AT SUBCRITICAL AND SUPERCRITICAL MACH NUMBERS

Stuart L. Treon, William R. Hofstetter, and Frank T. Abbott *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 8 p refs (See N72-11854 03-01)

(NASA-TM-X-67417) Avail NTIS HC $6.00/MF $0.95 CSCL 14B

The aerodynamic suitability of Freon 12 for general wind-tunnel testing was investigated at low and high subsonic speeds. Static aerodynamic characteristics of two transport airplane models were determined from strain gage balance measurements in both air and Freon-12 at several Reynolds numbers. A low-speed high-lift configuration was evaluated at Mach number 0.25, and a high-speed cruise wing-fuselage combination was tested at Mach numbers up to 0.825. The data obtained in air and in Freon-12 agree well, even in stalled flow, until compressibility effects evidently become significant in air and in Freon-12 agree well, even in stalled flow, until compressibility effects evidently become significant in air. Author

N72-11880*# National Aeronautics and Space Administration Langley Research Center, Langley Station, Va

A FACILITY CONCEPT FOR HIGH REYNOLDS NUMBER TESTING AT TRANSONIC SPEEDS

Donald D. Baals and George M. Stokes *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 12 p refs (See N72-11854 03-01)

(NASA-TM-X-67418) Avail NTIS HC $6.00/MF $0.95 CSCL 14B

The critical need for high Reynolds number experimental capability at transonic speeds has been broadly recognized, because there have been demonstrated significant transonic scale effects on wing-shock position with related effects on drag-rise Mach number, buffet boundary, and pitching-moment characteristics. Of the various ground-based transonic facilities considered for provision of high Reynolds number capability, the conventional wind tunnel operated in a semicontinuous mode and utilizing an energy storage system is considered to have the greatest potential. A hydropumped-storage system is proposed to provide hydraulic energy on an intermittent schedule at the rate of 500,000 horsepower to propel hydraulic turbines directly coupled to the wind-tunnel fans. Author

N72-11881# ARO, Inc., Arnold Air Force Station, Tenn. Von Karman Gas Dynamics Facility

HIGH REYNOLDS NUMBER TRANSONIC WIND TUNNELS. BLOWDOWN OR LUDWIEG TUBE?

Jack D. Whitfield, C. J. Schueler, and Rogers F. Starr *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 17 p refs (See N72-11854 03-01)

(Contract F40600-71-C-0002)

Avail NTIS HC $6.00/MF $0.95

The results are given of a detailed comparison between a conventional blowdown transonic wind tunnel and a Ludwieg tube driven transonic wind tunnel, both designed to cover the same Mach-Reynolds number regime. It is concluded that the Ludwieg tube driven tunnel will provide superior flow at a significantly lower cost. The data production capabilities of a Ludwieg tube driven tunnel, with appropriate design features, were surprisingly high. The production capability of the Ludwieg tube exceeds the conventional blowdown tunnel at very high Reynolds numbers and compares favorably with existing transonic tunnels at intermediate Reynolds numbers. Experimental results from a small Ludwieg tube-driven transonic research tunnel are presented and discussed. The research tunnel is equipped with variable porosity test section walls and an independently controlled plenum exhaust. Both static and dynamic pressure measurements are presented in preliminary form. Author

N72-11882*# National Aeronautics and Space Administration Marshall Space Flight Center, Huntsville, Ala

MSFC HIGH REYNOLDS NUMBER TUBE TUNNEL

A. Richard Felix *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 10 p refs (See N72-11854 03-01)

(NASA-TM-X-67419) Avail NTIS HC $6.00/MF $0.95 CSCL 14B

A high Reynolds number tube tunnel is described and illustrated by drawings and photographs. Its mode of operation and performance characteristics are also described. This impulse-type tunnel has a test section diameter of 32 inches and a Mach number range from 0.2 to 2.0. The transonic test section is equipped with a variable porosity perforated wall. A maximum unit Reynolds number of 200 million per foot is produced at a Mach number of 1.3 and the maximum tunnel charge pressure of 700 psig. The useful test time is 150 milliseconds or more at all operating conditions. Some typical test section calibration results are included. Author

N72-11883# Royal Aircraft Establishment, Farnborough (England)

SOME FACTORS RELEVANT TO THE SIMULATION OF FULL SCALE FLOWS IN MODEL TESTS AND TO THE SPECIFICATION OF NEW HIGH REYNOLDS NUMBER TRANSONIC TUNNELS

J. Y. G. Evans and C. R. Taylor *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug 1971 13 p refs (See N72-11854 03-01)

Avail NTIS HC $6.00/MF $0.95

Limitations and difficulties of achieving representative flow simulation in model tests are considered. Particular attention is given to obtaining design data for swept-winged aircraft at high lift coefficients, when the flow over the wing is locally transonic and sensitive to scale. Examination of the limitations due to model strength suggests that the maximum tunnel static pressure for tests at high lift conditions is about 5atm and consequently

that full scale Reynolds numbers could only be obtained in very large tunnels. Author

N72-11884# Advisory Group for Aerospace Research and Development, Paris (France).
AGARD STUDY OF HIGH REYNOLDS NUMBER WIND TUNNEL REQUIREMENTS FOR THE NORTH ATLANTIC TREATY ORGANIZATION NATIONS
Robert O. Dietz *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug. 1971 9 p (See N72-11854 03-01)
Avail: NTIS HC $6.00/MF $0.95

Performance and operating characteristics required in two new, high Reynolds number wind tunnels are defined, and conceptual tunnel designs which meet these requirements are given. One tunnel of the Ludwieg tube type should duplicate transonic flight Reynolds numbers and have a run time of about one second. The second, a blowdown type wind tunnel, should provide Reynolds numbers that are three or four times the maximum presently available and have a run time of about ten seconds. Author

N72-11885# Air Force Special Weapons Center, Holloman AFB, N.Mex.
HIGH REYNOLDS NUMBER TESTING BY MEANS OF ROCKET SLEDS
Hans J. Rasmussen *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug. 1971 8 p refs (See N72-11854 03-01)
Avail: NTIS HC $6.00/MF $0.95

Most aerodynamic ground testing is conducted in facilities which move air under controlled conditions over ground-fixed test models. This paper invites attention to the opposite approach. Aerodynamic ground testing by moving test specimen through ambient air along a rigorously defined straight line path by means of rocket sleds is reported. Some basic technical facets of rocket sled testing are reviewed and characteristics as well as current capabilities of this technique are discussed with emphasis on aerodynamic and structural design of the test vehicles, on typical test trajectories, and on electronic and photo-optical data acquisition. Similitude considerations governing aerodynamic testing by this technique are discussed and typical examples of past, current, and planned test activities in this area are reviewed. Concluding, merits and limitations of this technique as compared to other ground test approaches and to flight tests are outlined. Author

N72-11886# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
WIND TUNNEL INVESTIGATION OF BUFFET LOADS ON FOUR AIRPLANE MODELS
R. Vanino and E. Wedemeyer *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug. 1971 15 p refs (See N72-11854 03-01)
Avail: NTIS HC $6.00/MF $0.95

Buffet loads and buffet boundaries have been investigated in a transonic wind tunnel by measurements of bending moments at the wing roots for high subsonic Mach numbers. These tests were carried out for four airplane models having wings of different thicknesses and aspect ratios and also different angles of sweep. Simultaneous observation of oil flow patterns provided the means to study the relation between flow separation and buffeting. The test Reynolds numbers ranged from Re = 1 million to 2 million. Securing turbulent boundary layer at the shock position by means of artificial transition, no effect of Reynolds number of buffet boundaries was observed. For the models tested it was found that low sweep and low aspect ratio yield favorable buffet boundaries. Author

N72-11887# Royal Aircraft Establishment, Farnborough (England).
A SCHEME FOR A QUIET TRANSONIC FLOW SUITABLE FOR MODEL TESTING AT HIGH REYNOLDS NUMBER
J. Y. G. Evans *In* AGARD Facilities and Tech for Aerodyn Testing at Transonic Speeds and High Reynolds Number Aug. 1971 5 p refs (See N72-11854 03-01)
Avail: NTIS HC $6.00/MF $0.95

A wind tunnel suitable for future research and development towards better transonic aircraft should be able to achieve a Reynolds number, based on the mean chord of a typical swept-winged aircraft, of at least 40 million. Practical limits to model strength and stiffness dictate stagnation pressures below 7 atmospheres and consequently the test section must be at least 5 m in width. For this duty, a new type of facility is proposed, which combines the good driving efficiency of the continuous tunnel with the stored-energy advantage of intermittent running. Of particular importance, the tunnel would be relatively quiet to operate and should provide an extremely clean and steady flow. Author

N72-12978# Advisory Group for Aerospace Research and Development, Paris (France).
AERODYNAMIC TESTING AT HIGH REYNOLDS NUMBERS AND TRANSONIC SPEEDS
D. Kuechemann (Roy. Aircraft Estab., Farnborough, Engl.) Nov. 1971 9 p refs Presented at NATO Defence Res. Group Seminar on Gen. Probl. Relating to Aerodyn. Testing Facilities, St. Louis, France, 4-7 May 1971
(AGARD-R-588-71) Avail: NTIS

As a contribution to a NATO seminar on aerodynamic testing facilities held at the ISL from 4 to 7 May 1971, a brief report is given on the outcome of a specialists' meeting organized by the fluid dynamics panel of AGARD and held at Gottingen from 26 to 28 April 1971. Various AGARD activities, leading up to this meeting, are also briefly described. The best technical advice available within AGARD leads to the conclusion that one or several large new wind tunnels would contribute immensely to the effectiveness of a large number of aerospace systems now planned or contemplated within the NATO nations. Author

N72-22001# Advisory Group for Aerospace Research and Development, Paris (France).
SOME RECENT DEVELOPMENTS IN PLANAR INVISCID TRANSONIC AIRFOIL THEORY
H. Yoshihara (Gen. Dyn./Convair, San Diego, Calif.) Feb. 1972 38 p refs
(AGARD-AG-156; AGARDograph-156) Avail: NTIS

Some recent efforts to calculate planar inviscid supercritical flow over airfoils are reviewed giving typical results achieved. The hodograph procedures of Nieuwland and Boerstoel, and Garabedian and Korn are first reviewed which yield shockless profiles. The unsteady finite difference procedure of Mannus and Yoshihara is then described and its use then illustrated by several lifting examples with shocks. This is then followed by a description of two steady procedures. The first is that of Murman and Cole, who used a line relaxation procedure to solve a boundary value problem composed of the transonic perturbation equations with planar boundary conditions. The second is the procedure of Steger and Lomax who used the exact equations, and quasi-planar boundary conditions, and the finite difference relaxation procedure of Murman and Cole. The review is concluded by making a brief assessment of the various methods. Author

N73-14000# Advisory Group for Aerospace Research and Development, Paris (France).
UNSTEADY AERODYNAMICS OF HELICOPTER ROTORS
Oct. 1972 50 p refs Partly in ENGLISH, partly in FRENCH Presented at 34th AGARD Struct. and Mater. Panel Meeting, Lynbgy, Denmark, 11 Apr. 1972
(AGARD-R-595) Avail: NTIS HC $4.50

The proceedings of a conference on the unsteady aerodynamics of helicopter rotors are presented. Methods for improving the analytical prediction methods for assessing loads, loads, both

static and dynamic, exerted on rotor blades are discussed. Test data to evaluate the effectiveness of current analytical design procedures are correlated with analytical methods. Modifications of design procedures for design of future aircraft are examined. For individual titles, see N73-14001 through N73-14003.

N73-14001 Texas A&M Univ., College Station. Dept. of Aerospace Engineering Dept.
UNSTEADY AERODYNAMICS OF HELICOPTER ROTORS
W. P. Jones *In* AGARD Unsteady Aerodyn. of Helicopter Rotors Oct. 1972 23 p refs (For availability see N73-14000 05-01) (Grant DA-ARO(D)-31-124-71-G153)

Developments in the field of research on unsteady aerodynamics of helicopter rotors are presented. Advances in such problem areas as stall flutter of a retreating rotor blade, flutter of the advancing blade, transient effects due to the interaction of the tip-vortex of one blade with a following blade and wake induced instabilities in hovering and low speed flight are discussed. Attention is also drawn to aspects requiring additional research and, where possible, suggestions are made for new studies which could lead to further advancement of knowledge and understanding of the unsteady problems of helicopter rotor blades. Author

N73-14002 Army Air Mobility Research and Development Lab., Moffett Field, Calif.
DYNAMIC STALL OF AIRFOILS AND HELICOPTER ROTORS
W. J. McCroskey *In* AGARD Unsteady Aerodyn. of Helicopter Rotors Oct. 1972 7 p refs (For availability see N73-14000 05-01)

Model helicopter rotor tests to determine the characteristics of retreating blade stall are described. It is shown that the phenomenon may be modeled by the dynamic stall on an oscillating wing. The dynamic overshoot of the static stall conditions to show the shedding of a vortex-like disturbance from the leading edge is discussed. Application of classical static airfoil section data for predicting aerodynamic loads is explained. Author

N73-14003 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
COMPUTATION OF UNSTEADY AERODYNAMIC FORCES ON HELICOPTER ROTOR BLADES
Jean-Joel Costes *In* AGARD Unsteady Aerodyn. of the Helicopter Rotors Oct. 1972 16 p refs In FRENCH; ENGLISH summary (For availability see N73-14000 05-01)

Numerical methods for determining the unsteady aerodynamic forces on helicopter rotor blades are presented. The calculation of the velocity potential induced by a lifting surface element when its position, orientation, and lift are known is developed as a function of time. The collocation method makes it possible to express the lift distribution as a function of the velocity component normal to the blades on a network of collocation points distributed on the rotor disc. A comparison between theory and experiment in the case of forward flight is provided. Author

N73-22948# Advisory Group for Aerospace Research and Development, Paris (France). Fluid Dynamics Panel
HELICOPTER AERODYNAMICS AND DYNAMICS
Mar. 1973 378 p refs Lectures presented at Rhode-St.-Genese, Belgium, 2-6 Apr. 1973, sponsored in part by von Karman Inst. (AGARD-LS-63) Avail: NTIS HC $21.00

The role of aerodynamics and dynamics in helicopter development from the fundamental methods and principles through conceptual design to flight test and proof-of-concept is discussed. The subjects presented include the following: (1) applications of aerodynamics and dynamics to rotary wing aircraft, (2) basic aerodynamics and performance of the helicopter, (3) basic dynamics of rotary wings, (4) aeroelasticity of rotary wing aircraft, (5) helicopter noise analysis, (6) rotary wing model testing in wind tunnels, (6) selection of configuration and prototype design, and (7) flight testing for performance and flying qualities. For individual titles, see N73-22949 through N73-22959.

N73-22949 Army Air Mobility Research and Development Lab., Moffett Field, Calif.
THE ROLE OF AERODYNAMICS AND DYNAMICS IN MILITARY AND CIVILIAN APPLICATIONS OF ROTARY WING AIRCRAFT
Paul F. Yaggy *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 14 p (For availability see N73-22948 14-01)

The various aerodynamic and dynamic factors which influence the design of helicopters are discussed. The subjects presented are: (1) performance requirements; (2) dynamics, stability, and control; (3) airloads, aeroelasticity, and mechanical instabilities; and (4) proof of technology. Performance charts for typical helicopter configurations are included. Author

N73-22950 Boeing Co., Philadelphia, Pa. Vertol Div.
BASIC AERODYNAMICS AND PERFORMANCE OF THE HELICOPTER
W. Z. Stepniewski *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 62 p refs (For availability see N73-22948 14-01)

The fundamentals of rotary wing aerodynamics and their application to performance considerations of helicopters are discussed. The subjects presented are: (1) momentum theory; (2) blade element theory, (3) fundamentals of vortex theory, (4) applications of theory to design of rotary wing aircraft and performance optimization; and (5) example of helicopter performance prediction based on current industrial practice. Author

N73-22951 Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
BASIC DYNAMICS OF ROTORS: CONTROL AND STABILITY OF ROTARY WING AIRCRAFT; AERODYNAMICS AND DYNAMICS OF ADVANCED ROTARY-WING CONFIGURATIONS
G. Reichert *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 50 p refs (For availability see N73-22948 14-01)

Rotary wing configurations such as teetering, articulated, elastomeric-bearing, rotor hub, and hingeless systems are discussed. The basic dynamics of rotary wings are presented to show the elementary forces on a blade element, motion of rotary wing blades, and the influence of inplane stiffness, elastic coupling effects. The mechanics of helicopter flight are analyzed to demonstrate the principles of helicopter control, static and dynamic stability, and maneuver capability. The aerodynamics and dynamics of advanced rotary wing configurations are examined. Author

N73-22952 Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
AEROELASTICITY OF ROTARY WING AIRCRAFT
Rolland Dat *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 33 p refs (For availability see N73-22948 14-01)

The effects of aeroelasticity on the performance of rotary wing aircraft are discussed. Flutter instability is illustrated by the case of an airfoil and the theoretical tools used to investigate the flutter of a flexible wing are presented. Procedures for predicting the aerodynamic forces on the blades of rotary wings are developed. A formulation of the problem of forced vibration in forward flight is given. Mathematical models are included to support the theoretical considerations. Author

N73-22953 Loughborough Univ. of Technology (England).
HELICOPTER NOISE: ANALYSIS - PREDICTION AND METHODS OF REDUCTION
Martin V. Lowson *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 37 p refs (For availability see N73-22948 14-01)

The fundamentals of helicopter noise radiation phenomena are presented, to include a review of the features of subjective response. Emphasis is placed on the basic mechanisms of rotor noise generation, both for discrete frequency and broad band noise components. The implications for helicopter noise control are discussed. A review of possible propagation effects and the potential costs of helicopter noise reduction are included. Author

N73-22954 Societe Nationale Industrielle Aerospatiale, Marseille (France). Div. Helicopteres.
DRAG PROBLEMS ON ROTARY WING AIRCRAFT

Paul Fabre *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 12 p ref In ENGLISH and FRENCH (For availability see N73-22948 14-01)

The effects of aerodynamic drag on rotary wing performance are analyzed. The influence of stall and compressibility on rotor drag is examined. An example of parasite drag reduction by fairing the rotor head is presented. The nature of helicopter in-flight limitations and methods for improving performance through autogyro configuration and reduction of rotor rotational speed are submitted. Author

N73-22955 Boeing Co., Philadelphia, Pa. Vertol Div.

AERODYNAMIC AND DYNAMIC ROTARY WING MODEL TESTING IN WIND TUNNELS AND OTHER FACILITIES

Franklin D. Harris *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 62 p refs (For availability see N73-22948 14-01)

Procedures for testing models of rotary wing aircraft in wind tunnels are discussed. The test objectives involved in rotary wing tunnel tests are described. The characteristics of various testing facilities are analyzed and compared. Methods for obtaining and reducing wind tunnel data are presented. Cost considerations for models and test facilities are analyzed to provide basis for decision on construction and modification. Examples of typical wind tunnel tests conducted with rotary wing models are included. Author

N73-22956 Boeing Co., Philadelphia, Pa. Vertol Div.

FACTORS IN THE DESIGN AND FABRICATION OF POWERED DYNAMICALLY SIMILAR V/STOL WIND TUNNEL MODELS (APPENDIX 1)

Carl O. Albrecht *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 24 p refs (For availability see N73-22948 14-01)

The factors involved in the design of a wind tunnel for testing V/STOL aircraft models are discussed. Mach-scaled rotor systems are analyzed to show development and construction. A review of Mach-scaling and Froude-scaling is included to show the relative advantages of each method. Techniques for constructing the models are illustrated. The construction of the test stands and specialized test equipment is explained. Author

N73-22957 Boeing Co., Philadelphia, Pa. Vertol Div.

THE EFFECTS OF REYNOLDS NUMBER ON ROTOR STALL (APPENDIX 2)

William G. S. Hardy *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 8 p refs (For availability see N73-22948 14-01)

A theoretical analysis of the effects of Reynolds number on the aerodynamic stalling of rotary wings is presented. A comparison of full scale Reynolds number and model scale Reynolds number for specific airfoil configurations is made. The effects of aeroelasticity on rotary wing performance are analyzed. The relationship of Reynolds number to the aerodynamic coefficients of rotary wings is established. Author

N73-22958 Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).

PARAMETRIC TRENDS AND OPTIMIZATION; PRELIMINARY SELECTION OF CONFIGURATION, PROTOTYPE DESIGN AND MANUFACTURE

H. Huber *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 65 p refs (For availability see N73-22948 14-01)

The contribution of aerodynamic and dynamic inputs to the design synthesis of rotary wings is discussed. Aerodynamic rotor design is concentrated on disc loading, tip speed, and solidity selection. Rotor airfoil design is examined under the aspects of compressibility and stall problems. Fundamental flapping and inplane frequencies are shown to be the two basic parameters in dynamic rotor design. Methods of developing various trend curves and their interpretation is supplemented by formal and iterative optimization techniques. Author

N73-22959 Westland Helicopters, Ltd., Yeovil (England).

FLIGHT TESTING FOR PERFORMANCE AND FLYING QUALITIES

Kieran T. McKenzie *In* AGARD Helicopter Aerodyn. and Dyn. Mar. 1973 15 p (For availability see N73-22948 14-01)

A review is presented of the required approach to flight testing of rotary wing aircraft in the major areas of performance and flying qualities. Program philosophies, problem areas, techniques of measurement, recording, and analysis are examined and discussed. Some sample measurements and procedures are examined to illustrate approaches. Author

N74-10906# Ministry of Defence, London (England).

TECHNICAL EVALUATION REPORT ON FLUID DYNAMICS PANEL SPECIALISTS' MEETING ON AERODYNAMIC DRAG

S. F. J. Butler Paris AGARD Sep. 1973 14 p refs Conf. held at Izmir, Turkey, 10-13 Apr. 1973

(AGARD-AR-58) Avail: NTIS HC $3.00

The proceedings of a conference on the development of methods for predicting aerodynamic drag are presented. The subjects discussed are: (1) aircraft and wing drag characteristics, (2) helicopter drag, (3) base drag and separation, (4) interaction effects, (5) hypersonic drag, and (7) testing techniques for flight and wind tunnel comparisons. Author

N74-13709*# Advisory Group for Aerospace Research and Development, Paris (France).

DYNAMIC STALL

P. Crimi (Avco Corp., Wilmington, Mass.) and P. F. Yaggy, ed. (Army Air Mobility Res. and Develop. Lab., Moffett Field, Calif.) Nov. 1973 41 p refs Sponsored by NASA

(NASA-CR-136473; AGARD-AG-172) Avail: NTIS HC $4.25 CSCL 01A

Problems associated with unsteady stall are summarized and past experimental and theoretical studies, relating primarily to dynamic stall of helicopter rotor blades, are reviewed. The problems attendant to analytic treatment of dynamic stall, including identification of relevant flow elements and definition of unsteady separation, are then discussed, and the basis for a theory which accounts for viscous effects and viscous-inviscid interactions analytically is presented. Results of computations are compared with measured loading on an airfoil undergoing sinusoidal pitching motion. The amounts of lift overshoot and their variation with frequency are in good agreement. Analyses of wake-induced stall and stall flutter of a helicopter rotor blade are then presented. The results indicate that the large stall-related torsional oscillations which commonly limit helicopter forward speed are the response to rapid changes in aerodynamic moment which accompany stall and unstall, rather than the consequence of an aeroelastic instability. Author

N74-13710# Advisory Group for Aerospace Research and Development, Paris (France).

MAGNUS CHARACTERISTICS OF ARBITRARY ROTATING BODIES

I. D. Jacobson (Va. Univ.) and P. F. Yaggy, ed. (Army Air Mobility Res. and Develop. Lab., Moffett Field, Calif.) Nov. 1973 62 p refs

(AGARD-AG-171) Avail: NTIS HC $5.25

Theoretical and experimental investigations of the Magnus effect on arbitrary bodies of revolution are reviewed. The main emphasis is on spinning projectiles at angle of attack, both with and without fins. Flow visualization measurements are used to assess the accuracy of the existing theories. Laminar, turbulent and mixed boundary layers are considered. Author

N74-14709# Advisory Group for Aerospace Research and Development, Paris (France).

AERODYNAMIC DRAG

Oct. 1973 469 p refs Partly in ENGLISH and partly in FRENCH Proc. of the Fluid Dyn. Panel Specialists Meeting, Izmir, Turkey, 10-13 Apr. 1973

(AGARD-CP-124) Avail: NTIS HC $25.50

The proceedings of a conference on aerodynamic drag are presented. Current research and future prospects in the field of

aerodynamic drag are considered. Main emphasis was placed on subjects of practical value to the aerospace industry in relation to the need for accurate prediction, measurement, and alleviation of drag. Some of the subjects considered are: (1) aircraft drag, (2) wing drag, (3) base drag and separation, (4) interaction effects, (5) hypersonic drag, and (6) testing techniques and correlation of flight test and wind tunnel test data. For individual titles, see N74-14710 through N74-14738

N74-14710 Ministry of Defence, London (England)
TECHNICAL EVALUATION REPORT
S F J Butler *In* AGARD Aerodyn Drag Oct 1973 11 p (For availability see N74-14709 06-01)

A primary objective of research on aerodynamic drag is the development and proving of prediction methods in a form suitable for direct use by aircraft development teams and by those who have to assess the relative merits of alternative designs. Aircraft drag estimation methods are needed at various levels of sophistication and reliability. Basic statistical analyses can form the basis of an acceptable forecasting procedure at the feasibility stage, although such an approach is essentially conservative and can lead to the perpetuation of low design standards, as well as being of little use when novel aircraft design concepts are under consideration. Of some significance is the ability to predict reliably the drag of a datum streamlined aircraft with fully-turbulent flow, against which achieved drag levels can be compared in a figure-of-merit approach. During the design development and refinement stage, the research aims include the achievement of drag design objectives and the limitation of drag growth. In this phase, drag predictions in practice must be prepared by a process of synthesis (rather than simple summation), within a format which can readily accommodate the changing sources of data. Author

N74-14711 Lockheed-Georgia Co., Marietta
A SURVEY OF DRAG PREDICTION TECHNIQUES APPLICABLE TO SUBSONIC AND TRANSONIC AIRCRAFT DESIGN
J H Patterson, D G MacWilkinson, and W T Blackerby *In* AGARD Aerodyn Drag Oct 1973 38 p refs (For availability see N74-14709 06-01)

The following aspects of aircraft drag prediction in the subsonic to transonic range are discussed: (1) preliminary estimation procedures, (2) estimation using wind tunnel test data, and (3) wind tunnel data and flight test data correlation. Inaccuracies in the approach to the use of flat plate skin friction, with appropriate shape factors, to predict profile drag are identified. Attempts to use low Reynolds number wind tunnel drag levels to predict full scale drag are shown to be reasonably successful. The prediction of C-5A aircraft drag characteristics from wind tunnel tests is discussed. Author

N74-14712 Naval Weapons Lab., Dahlgren, Va
AERODYNAMIC DRAG AND LIFT OF GENERAL BODY SHAPES AT SUBSONIC, TRANSONIC AND SUPERSONIC MACH NUMBERS
Frankie G Moore *In* AGARD Aerodyn Drag Oct 1973 11 p refs (For availability see N74-14709 06-01)

Several theoretical and empirical methods are combined into a single computer program to predict drag, lift, and center of pressure on bodies of revolution at subsonic, transonic, and supersonic Mach numbers and for angles of attack to twenty degrees. The body geometries can be quite general in that pointed, spherically blunt, or truncated noses are allowed as well as discontinuities along the nose. Particular emphasis is placed on methods which yield accuracies of ninety percent or better for most configurations but yet are computationally fast. To handle the blunt nosed configurations, a new procedure has been employed: that of combining modified Newtonian theory with perturbation theory. Theoretical and experimental results are presented for several projectiles and the comparisons meet the general accuracy requirements above. The combined perturbation - Newtonian theory gave pressures which compared better with experiment than any existing approximate technique in the lower supersonic speed regime. Author

N74-14713 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Aerodynamik
ON SOME BASIC AND NEW ASPECTS ABOUT THE DRAG PROBLEM OF WINGS AND BODIES IN SUPERSONIC FLOWS
Arabindo Das *In* AGARD Aerodyn Drag Oct 1973 26 p refs (For availability see N74-14709 06-01)

With the objective to determine optimum shapes of slender wings and bodies for minimum total drag in supersonic flows a comprehensive theoretical and experimental analysis of the problem has been carried out. The theoretical formulas for the various drag components which are necessary for a variational problem of drag minimization have been reviewed, summarized, partly modified or extended, and finally compared with experimental values. Based on the linearized mass flux concept already known in the literature a modified boundary condition leads to a certain improvement in the results of the linear theory. A simplified treatment of the modified linear theory is presented. A unified approach to the problem of minimization of wave drag due to volume and wave drag due to lift yields very simple analytical results. The optimum body shapes show a certain dependence on Mach number. For minimization of vortex drag the necessary wing twist yields a remarkable improvement, which could also be verified by experiment. While the known friction drag formulas from the literature have been checked with experimental values, the problem of base drag of axial symmetrical bodies has not been completely solved as yet, theoretical work on this topic is being continued. Author

N74-14714 Royal Aircraft Establishment, Bedford (England)
MEASUREMENTS OF THE DRAG OF SOME CHARACTERISTIC AIRCRAFT EXCRESCENCES IMMERSED IN TURBULENT BOUNDARY LAYERS
L Gaudet and K G Winter *In* AGARD Aerodyn Drag Oct 1973 12 p refs (For availability see N74-14709 06-01)

Measurements are described of the drag of various forms of excrescence mounted on balances installed in the walls of the working section of the RAE 8ft x 8ft wind tunnel. The tests cover a range of Mach numbers between 0.2 and 2.8 (but not transonic) and a range of Reynolds number. The excrescences tested include two-dimensional steps and ridges, circular cylinders and wings mounted normal to the surface, and holes and fairings. It is shown, for excrescences which are of height small compared with the boundary-layer thickness, that the scale effects on drag are well correlated in terms of the wall variables of the turbulent boundary layer, but that there is a dependence of drag on Mach number. For steps and ridges the effect of chamfering or rounding the upper corners was found to be beneficial at subsonic speeds but far less so at supersonic speeds. For circular holes the drag depends strongly upon the depth to diameter ratio. The fairings tested were either half-bodies of revolution with pointed or rounded ends or of square or rectangular section with pointed ends. The effects of different amounts of immersion of the bodies into the boundary layer was found in some cases by testing geometrically similar bodies of different sizes. Author

N74-14715 Messerschmitt-Boelkow-Blohm G m b H, Ottobrunn (West Germany)
PROBLEMS OF ESTIMATING THE DRAG OF A HELICOPTER
S N Wagner *In* AGARD Aerodyn Drag Oct 1973 12 p refs (For availability see N74-14709 06-01)

The components which contribute to the drag of a helicopter are identified as (1) the drag of the main and tail rotors, (2) fuselage drag, (3) pylon drag, (4) landing gear drag, (5) fairing drag, and (6) drag caused by interference between the helicopter components. The difficulties and advantages of methods for defining the drag of a helicopter are analyzed. Procedures for testing small scale models of helicopters are discussed. The correlation of model data with flight test data is examined. Author

N74-14716 Royal Aircraft Establishment, Farnborough (England)
AIRCRAFT DRAG PREDICTION FOR PROJECT APPRAISAL

AND PERFORMANCE ESTIMATION
S F J Butler *In* AGARD Aerodyn Drag Oct 1973 50 p (For availability see N74-14709 06-01)

The principal stages in aircraft feasibility study and design development are considered, leading to the specification of desirable characteristics of aircraft drag prediction models The contributions to drag modelling to be expected from research are reviewed, together with the impact of computerized design selection and mission analysis methods An assessment of the relative importance of different components and sources of drag introduces surveys, which examine the present state of the art of prediction for specific classes of aircraft and for particular aspects of drag The main problems involved in executing and analysing model and aircraft tests are also discussed in the drag context The collection, analysis and dissemination of data suitable for direct use in practical design methods are discussed Author

N74-14717 Engineering Sciences Data Unit, London (England)
APPENDIX: A DATA ITEM SERVICE FOR AIRCRAFT DRAG ESTIMATION
In AGARD Aerodyn Drag Oct 1973 9 p refs (For availability see N74-14709 06-01)
Avail NTIS

The terms of reference for an engineering unit concerned with determining aerodynamic drag are discussed The functions of the organization are defined (1) to collect and disseminate information on drag prediction for sweptwing aircraft, (2) to arrange for the correlation and analysis of relevant data, (3) to formulate a comprehensive framework for the analysis and synthesis of aircraft drag, and (4) to encourage the introduction and adoption of improved drag prediction methods Author

N74-14718 Douglas Aircraft Co , Inc , Long Beach, Calif
REMARKS ON METHODS FOR PREDICTING VISCOUS DRAG
A M O Smith and Tuncer Cebeci *In* AGARD Aerodyn Drag Oct 1973 12 p refs (For availability see N74-14709 06-01)

While predictions of low speed profile drag are accurate for monoelement airfoils at low angle of attack, the methods are not very accurate at higher angles of attack, or for multielement airfoils or for fatter bodies of revolution Two courses that might lead to possible improvement in accuracy have been investigated One was an attempt to perform direct shear and pressure stress calculations on an airfoil or body The other was an attempt to improve the Squire-Young momentum defect method by actually solving the wake for a short distance The first method was not successful but the second method shows promise Hence, it is tentatively concluded that refinement of the momentum defect method is the most promising path towards improved accuracy Author

N74-14719 National Aeronautical Establishment, Ottawa (Ontario)
DRAG OF SUPERCRITICAL AIRFOILS IN TRANSONIC FLOW
J J Kacprzynski *In* AGARD Aerodyn Drag Oct 1973 20 p refs (For availability see N74-14709 06-01)

Analytical methods of evaluation of drag coefficients of contemporary supercritical airfoils are discussed Some results of experimental values of drag coefficient for supercritical airfoils are compared against results of theoretical evaluations Some results of drag coefficients of conventional airfoils are included for comparison Difficulties of accurate experimental recording of drag coefficients are indicated Author

N74-14720 General Dynamics/Convair, San Diego, Calif Aerospace Div
TRANSONIC DRAG DUE TO LIFT OF PLANAR JET-FLAPPED AIRFOILS
H Yoshihara R Magnus and D Zonars (AFFDL) *In* AGARD Aerodyn Drag Oct 1973 8 p refs (For availability see N74-14709 06-01)

In contrast to the low speed case test results indicate that lift augmentation by the jet flap in the transonic regime is accompanied, not by a large thrust recovery, but by a significant increase in drag However to achieve moderate to high lifts the use of jet flaps rather than incidence has led to a significant reduction in the drag due to lift To calculate the transonic jet flap flow a modified Spence jet flap condition is postulated and incorporated into the (unsteady) finite difference procedure An example is then calculated and compared with experimental results Author

N74-14721 National Aerospace Lab., Amsterdam (Netherlands)
COMPARISON OF VARIOUS METHODS FOR CALCULATING PROFILE DRAG FROM PRESSURE MEASUREMENTS IN THE NEAR WAKE AT SUBCRITICAL SPEEDS
J Zwaaneveld *In* AGARD Aerodyn Drag Oct 1973 12 p refs (For availability see N74-14709 06-01)

Methods for calculating the profile drag from total and static pressure measurements in aircraft wake have been compared An analytical model of a compressible two-dimensional wake is used to obtain numerical results Both the oldest method of Betz and the widely used method of Jones allow the static pressure variation across the wake to be taken into account These methods are therefore suitable to treat the flow in the very near wake The third method developed by Squire and Young is in principle only valid when the static pressure variation across the wake is negligible To extend this method to the more general case, two modifications are considered, the first as proposed by Squire and Young, the second as presented by the author The latter modification makes use of the momentum integral equation with modified parameters The numerical results show this new approach to be in far better agreement with the method of Jones than the first mentioned modified version Author

N74-14722 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
DRAG AND SEPARATION
Maurice Sirieix *In* AGARD Aerodyn Drag Oct 1973 23 p refs In FRENCH, ENGLISH summary (For availability see N74-14709 06-01)

The unsteady character of some separated flows and their resulting effects are discussed The different types of turbulent separated flows of a limited extent and quasi-steady character are defined The expected effects of these separated flows on the aerodynamic drag were studied Theoretical methods of prediction are explained Examples in which separated flows appear are analyzed Author

N74-14723 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)
NEW INVESTIGATIONS FOR REDUCING THE BASE DRAG OF WINGS WITH A BLUNT TRAILING EDGE
Mauri Tanner *In* AGARD Aerodyn Drag Oct 1973 9 p refs (For availability see N74-14709 06-01)

Investigations were conducted to determine methods for reducing the base drag of wings with blunt trailing edges Measurements were performed on a rectangular wing in a low speed wind tunnel The wing was fitted with broken trailing edges, splitter plates and splitter wedges The tests showed that the base drag could be substantially reduced by fitting a splitter wedge on the trailing edge For the most advantageous splitter wedge, the base drag was nearly zero In this case the maximum lift to drag ratio for the wing with a blunt trailing edge was as great as that for the corresponding wing with a conventional sharp trailing edge Author

N74-14724 Illinois Univ , Urbana Dept of Mechanical and Industrial Engineering
A STUDY OF FLOW SEPARATION IN THE BASE REGION AND ITS EFFECTS DURING POWERED FLIGHT
A L Addy, H H Korst, R A White and B J Walker (Army Missile Command, Redstone Arsenal, Ala) *In* AGARD Aerodyn Drag Oct 1973 15 p refs (For availability see N74-14709 06-01)

The effect of the separated flow region on the performance of aircraft and missiles during powered flight is discussed. The interaction between the propulsive jet and the free stream flows is emphasized. The Chapman-Korst component flow model allows the qualitative and quantitative discussion of the effects of the afterbody-base problem of all pertinent design and performance parameters. The usefulness of the component approach has been enhanced by semi-empirical modifications, improvements of individual components, and the development of computer programs. It is shown that the onset and location of plume-induced separation of the external flow can be predicted given a suitable boundary layer separation criterion. Author

N74-14725 LTV Aerospace Corp., Dallas, Tex.
PREDICTION OF BUFFET ON-SET FOR AIRCRAFT, RECENT PROGRESS IN WIND TUNNEL AND FLIGHT TEST DATA CORRELATION
R. C. McWherter *In* AGARD Aerodyn. Drag Oct. 1973 8 p refs (For availability see N74-14709 06-01)

Methods for predicting and determining the onset of buffet during aircraft flight are analyzed. The buffet characteristics of F-4 and F-8 aircraft are reported. Diagnostic data on wind tunnel flow is examined to determine the property or properties which are necessary to obtain repeatable, sensible buffet onset predictions from model testing. The characteristics of wind tunnels which affect the results of buffet investigations are examined. Author

N74-14726 Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
ASSESSMENT OF THE INFLUENCE OF INLET AND AFTBODY/NOZZLE PERFORMANCE ON TOTAL AIRCRAFT DRAG
Philip P. Antonatos, Lewis E. Surber, James A. Laughrey, and Donald J. Stava *In* AGARD Aerodyn. Drag Oct. 1973 28 p refs (For availability see N74-14709 06-01)

The influence of propulsion system installation on aircraft drag is discussed. Using information from several investigations, different aspects of airframe propulsion integration are explored, each of which affects the assessment of aircraft drag. A great deal of apparently conflicting data has been generated on airframe-propulsion integration simply because the investigators concerned with different aspects of a system development have not properly integrated their own efforts to assure that theoretical analysis methods are consistent with wind tunnel test methods, that the test models are consistent with each other, and that adequate corrections for the effect of model mounting systems can be made. Even rather small inconsistencies in just a few of these considerations may result in errors of sufficient magnitude to affect aircraft design decisions adversely. A major part of the difficulty of making an accurate assessment of inlet/aftbody nozzle effect on aircraft drag is the prediction of flight performance from wind tunnel test data. Early system development should be studied carefully to assure that the program of airframe-propulsion integration and the demands on propulsion related drag assessment are consistent with drag estimate accuracy for the airframe. Author

N74-14727 Boeing Commercial Airplane Co., Renton, Wash.
THE PROBLEM OF INSTALLING A MODERN HIGH BYPASS ENGINE ON A TWIN JET TRANSPORT AIRCRAFT c02
Walter C. Swan and Armand Sigalla *In* AGARD Aerodyn. Drag Oct. 1973 12 p (For availability see N74-14709 06-01)

An examination of the engine placement on a modern jet transport presents new drag and stability problems. Large high bypass ratio engines create large annular and wetted area drag and blockage surfaces which can cause difficult configuration problems as well as large interference drag and stability effects. The option is open to conventional underwing and aftbody mounted installations as well as renewed opportunity for over-the-wing installations. In this paper the drag and stability consequences for each class of configuration is examined for a typical intermediate range transport. The results are equally valid for short haul and certain STOL missions. In some instances it is shown, proper pod shape and positioning may result in favorable drag increments, especially on modern swept wings with supercritical airfoil sections. Side effects such as pod influences on wing flutter, deep stall, and general sizing of the empennage are discussed. Author

N74-14728 National Aeronautical Establishment, Ottawa (Ontario).
THE DRAG RESULTING FROM THREE-DIMENSIONAL SEPARATIONS CAUSED BY BOUNDARY-LAYER DIVERTERS AND NACELLES IN SUBSONIC AND SUPERSONIC FLOW
David J. Peake and William J. Rainbird (Carleton Univ.) *In* AGARD Aerodyn. Drag Oct. 1973 22 p refs (For availability see N74-14709 06-01)

Three-dimensional viscous flow separations and their effect on configuration drag are examined in high Reynolds number tests conducted in the NAE 5-ft x 5-ft blowdown wind tunnel in both subsonic and supersonic flow. In particular, emphasis is placed on the geometry of the system to divert the oncoming boundary layer about propulsion nacelles. To avoid significant three-dimensional separations, avoid imposing large adverse streamwise pressure gradients upon an oncoming boundary layer, such as those produced near stagnation point regions of bluff diverters, or adjacent to intakes operating below design mass flow. The avoidance of these strong streamwise pressure gradients is seen to be readily achieved by increasing the diverter slenderness ratio and by keeping intakes operating at design conditions by means of auxiliary by-pass arrangements. Author

N74-14729 Royal Aircraft Establishment, Bedford (England).
THE DRAG OF EXTERNALLY CARRIED STORES: ITS PREDICTION AND ALLEVIATION
P. G. Pugh and P. G. Hutton *In* AGARD Aerodyn. Drag Oct. 1973 11 p refs (For availability see N74-14709 06-01)

The installed drag of stores makes a major contribution to the total drag of combat aircraft. It can be several times the sum of the free-air drags of the individual stores and its prediction and reduction are essential to the design of high-performance aircraft. Interference effects involved range from simple buoyancy to complex interactions involving viscous and wave drag phenomena. For the simpler cases there are good prospects that the installed drag can be accurately predicted either by current methods or by relatively straightforward extensions of these. However, empirical methods will continue to be needed for the prediction of the drag of complicated cases eg multiple store arrays at transonic speeds. Some examples are given to show the opportunities for reducing the installed drag either by redesigns to take advantage of improved mechanical systems or through the development of radically new installations. Author

N74-14730 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany).
DRAG IN HYPERSONIC RAREFIED FLOW
Walter Wuest *In* AGARD Aerodyn. Drag Oct. 1973 12 p refs (For availability see N74-14709 06-01)

The drag force in hypersonic flow may be divided into cold pressure drag (incident molecules), temperature depending pressure drag (diffusively reflected molecules) and friction drag. The pressure drag dominates on blunt bodies which show a slighter drag variation with rarefaction whereas on slender bodies friction drag dominates and the total drag is strongly influenced by rarefaction. Relaxation and radiation do not appreciably alter the pressure drag but influence the flow field, stand-off distance of shock wave, and heat transfer. Author

N74-14731 Centre National de la Recherche Scientifique, Meudon (France). Lab. d'Aerothermique.
DRAG OF LIFTING BODIES FOR PILOTS AT HIGH ALTITUDE [TRAINEE DE CORPS PORTANTS PILOTES A HAUTE ALTITUDE]
J. Allegre, C. Matrand, and M. F. Scibilia *In* AGARD Aerodyn. Drag Oct. 1973 10 p refs In FRENCH; ENGLISH summary (For availability see N74-14709 06-01)

Lifting bodies with 60 deg swept delta wings fitted out with control devices, located near the trailing edge of the wings are analyzed. The present experimental study of the aerodynamic

behaviour of the wing is realized in a rarefied flow simulating a flight altitude of about 70 km. Experiments are performed in an open jet and continuously operating wind tunnel. The air flow is characterized by a Mach number of 8.1 and a free stream Reynolds number of 2200 per cm. Results show how much aerodynamic devices associated with the delta wing, like spoilers, remain efficient and can be used in order to control the trajectory at high altitude. Drag coefficient data are given in the range of incidences between minus 20 deg and 20 deg. A comparison between efficiencies of trailing edge solid spoilers and trailing edge fluid spoilers allows to point out some advantages of the fluid spoilers. In particular, this jet control mechanism can create a sufficient side thrust without entailing a large increase of the drag. Author

N74-14732 Aeritalia, Turin (Italy)
A REVIEW OF SUPERSONIC SPHERE DRAG FROM THE CONTINUUM TO THE FREE MOLECULAR FLOW REGIME
E. Vallerani *In* AGARD Aerodyn Drag Oct 1973 15 p refs (For availability see N74-14709 06-01)

The evaluation of the sphere drag coefficient has been the object of extensive theoretical investigations for a long time. A large amount of experimental data has been collected to substantiate those studies and to provide the needed information for the flow regimes for which the theoretical approaches are still missing. The scope of the present review is to attempt the establishment of a more complete panorama of the supersonic sphere drag predictions over the entire range of flow regimes ranging from the continuum flow to the free molecular flow, in order to provide in a consistent form the design engineer of the information required for the aerodynamic design of space vehicles. The theoretical methods developed to cover the various flow regimes such as: (1) continuum low density, (2) free molecular, (3) near free molecular, and (4) intermediate have been reviewed and discussed in the light of the comparison with the pertinent experimental data available. New semiempirical formulas for the correlation of the experimental data are derived for the low density continuum flow and for the near free molecule flow regimes. For the intermediate flow regimes, ranging between the continuum flow and the free molecular flow, the results of a semiempirical method recently developed by the author are presented and discussed. Author

N74-14733 Ruhr Univ., Bochum (West Germany)
THE INFLUENCE OF WAVE DRAG ON HYPERSONIC ENTROPY WAKE OBSERVATIONS
Wolfgang Merzkirch and Alois Stilp (Ernst-Mach-Inst.) *In* AGARD Aerodyn Drag Oct 1973 6 p refs (For availability see N74-14709 06-01)

The conditions existing in the wake of a blunt hypersonic body are discussed. The two different flow regimes are defined as: (1) the viscous wake which originates from the separated boundary layer and (2) the inviscid or entropy wake formed by the streamlines which have traversed the curved part of the bow shock. The flow visualization of the entropy wake by schlieren photography is described. The observed schlieren pattern is analyzed with the aid of optical schlieren theory and can be related to the flight Mach number and the drag coefficient of the body. Author

N74-14734 Naval Air Systems Command, Washington, D.C.
DEVELOPMENT OF TECHNIQUES TO MEASURE IN-FLIGHT DRAG OF A US NAVY FIGHTER AIRPLANE AND CORRELATION OF FLIGHT MEASURED DRAG WITH WIND TUNNEL DATA
E. C. Rooney *In* AGARD Aerodyn Drag Oct 1973 18 p (For availability see N74-14709 06-01)

Wind tunnel and flight drag measurement techniques and correlation of wind tunnel and flight drag data for a U.S. Navy fighter airplane are discussed. Wind tunnel drag data were obtained with aerodynamic, induction system and powered nozzle/afterbody models. A common reference afterbody configuration between aerodynamic and propulsion models was utilized to assure compatibility of thrust and drag measurements. Flight drag data were obtained from steady-state, quasi steady-state and dynamic (wind-up/down turn) maneuvers utilizing sensitive three-axis accelerometers to determine excess thrust and the internal pressure method for measuring engine thrust. Compressor airflow, afterburner pressure drop and nozzle coefficients used for computing engine net thrust were obtained from isolated engine tests at simulated flight conditions throughout the flight envelope. Wind tunnel data were used to account for propulsion system drag caused by subcritical inlet spillage and nozzle interference drag. Author

N74-14735* National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
REVIEW OF DRAG MEASUREMENTS FROM FLIGHT TESTS OF MANNED AIRCRAFT WITH COMPARISONS TO WIND-TUNNEL PREDICTIONS
Jon S. Pyle and Edwin J. Saltzman *In* AGARD Aerodyn. Drag Oct. 1973 12 p refs (For availability see N74-14709 06-01)

In-flight studies of the overall and local components of drag of many types of aircraft were conducted. The primary goal of these studies was to evaluate wind-tunnel and semiempirical prediction methods. Some evaluations are presented in this paper which may be summarized by the following observations. Wind-tunnel predictions of overall vehicle drag can be accurately extrapolated to flight Reynolds numbers, provided that the base drag is removed and the boattail areas on the vehicle are small. The addition of ablated roughness to lifting body configurations causes larger losses in performance and stability than would be expected from the added friction drag due to the roughness. Successful measurements of skin friction have been made in flight to Mach numbers above 4. A reliable inflatable deceleration device was demonstrated in flight which effectively stabilizes and decelerates a lifting aircraft at supersonic speeds. Author

N74-14736 Royal Armament Research and Development Establishment, Fort Halstead (England)
AN ASSESSMENT OF THE ACCURACY OF TRANSONIC DRAG MEASUREMENT IN A LARGE MODERN WIND TUNNEL
K. Fancett and T. Smith *In* AGARD Aerodyn Drag Oct 1973 11 p refs (For availability see N74-14709 06-01)

The aeroballistic coefficients of bodies of revolution are needed for the mathematical modelling of their trajectories. The most significant coefficient required is zero yaw drag and the accuracy required is about 0.5% for a perfect trajectory model, compared with about 5% for lift and overturning moment. Lift, drag and overturning moment were measured over a range of yaw angles on two sting lengths in a 2.4 m x 2.7 m transonic wind tunnel. There was a marked difference in the measured drag values for these stings and a further investigation was made with five sting lengths. From these tests an empirical correction for the support system was derived which agreed well with a subsonic theoretical estimate. At speeds above Mach 1.0 the irregularity of the tunnel axial pressure distribution dominated the effects due to the support sytem and a combined correction was derived. It was found that the difference in measured values after correction was very much less than before, over the whole Mach number range, thus supporting the correction procedure applied. A statistical analysis of the residual coefficient errors has been summarized for the subsonic and transonic speed regions. The transonic percentage errors were generally less than the subsonic values, due to the larger coefficient values measured. Author

N74-14737 City Univ., London (England). Dept. of Aeronautics
STING INTERFERENCE EFFECTS ON AFTERBODIES AT TRANSONIC SPEEDS
D. M. Sykes *In* AGARD Aerodyn Drag Oct 1973 9 p refs (For availability see N74-14709 06-01)

The pressure distribution over the surface of three axisymmetric afterbodies at zero incidence has been measured and sting interference effects determined through the Mach number range from 0.70 to 1.15 in an octagonal, slotted wall wind tunnel. The afterbodies tested were a simple cylinder and conical boat-tails 1/2 calibre long with 7 1/2 deg angle and 1 calibre

long with 9 deg angle, each carrying a representative driving band. Sting diameter effects were determined using 4 calibre long cylindrical stings of diameter 1/8, 1/4, 3/8 and 1/2 calibre, and sting-flare interference effects were determined for a 10 deg semi-angle cone on a 1/4 calibre sting. The tests showed that the ratio of sting to base diameter was the main parameter for interference effects, but data for diameter effect from afterbodies with other geometries was not fully correlated using this parameter. Successful correlation with other data has been achieved for the proximity of conial flares of different angles for subsonic flow conditions. Author

N74-14738 Laboratoire de Recherches Balistiques et Aerodynamiques, Vernon (France)

MEASUREMENT OF DRAG IN A SHOCK TUNNEL [MESURES DE TRAINEE EN TUNNEL DE TIR]

Daniel Bahurel and Alain Desgardin *In* AGARD Aerodyn. Drag Oct. 1973 14 p refs In FRENCH (For availability see N74-14709 06-01)

After summarizing the principles of drag measurement in a shock tunnel, the different methods actually used are given: Cx constant, Cx as a function of incidence, and Cx as a function of Mach number. The accuracy of the methods is included. A series of results, obtained in the L.R.B.A. shock tunnel, on sphero-conic and cylindo-conic projectile slip over a broad range of Mach numbers and at 15 degree incidence angle are presented. Transl. by E.H.W.

N74-18652*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

COMMENTS ON NASA LANGLEY RESEARCH ON TRANSONIC UNSTEADY AERODYNAMICS

Samuel R. Bland Paris AGARD Dec. 1973 14 p refs Presented at 36th AGARD Structures and Mater. Panel Meeting, Milan, 4 Apr. 1973

(NASA-TM-X-69997; AGARD-R-611) Avail: NTIS HC $4.00 CSCL 01A

Accurate unsteady transonic aerodynamics for use in flutter calculation are considered. Five different methods of analysis are described, each of which attempts to treat some of the nonlinear aspects of the transonic flow. Where possible, calculated results are given. Author

N74-18653# Advisory Group for Aerospace Research and Development, Paris (France).

ON THE PREDICTION OF AERODYNAMIC LOADS ON OSCILLATING WINGS IN TRANSONIC FLOW

H. Tijdeman (Natl. Aerospace Lab., Amsterdam) and R. J. Zwaan (Natl. Aerospace Lab., Amsterdam) Jan. 1974 30 p refs Presented at 36th AGARD Structures and Mater. Panel Meeting, Milan, 4 Apr. 1973

(AGARD-R-612) Avail: NTIS HC $4.50

Possibilities to develop calculation methods for oscillating wings in transonic flow are discussed. Special attention is given to the question of linearization. Pressure measurements on an aerofoil with flap in transonic flow are analyzed. Correlations are made between steady, quasi-steady and unsteady results. Shock motion and shock strength are investigated. Also linearity is discussed. A calculation method for high subsonic flow is suggested. Author

N74-18654# Advisory Group for Aerospace Research and Development, Paris (France).

INTERFERING LIFTING SURFACES IN UNSTEADY SUBSONIC FLOW: COMPARISON BETWEEN THEORY AND EXPERIMENT

Juergen Becker (Messerschmitt-Boelkow-Blohm, Munich) Jan. 1974 20 p refs Presented at 37th AGARD Structures and Mater. Panel Meeting, the Hague, 7-12 Apr. 1973

(AGARD-R-614) Avail: NTIS HC $4.00

The results of experimental and analytical research work on the flutter with complete aircraft models showed considerable shifting of critical flutter speeds due to interfering aerodynamic forces, particularly where models of variable geometry were concerned. This was the reason for the development of aerodynamic interference procedures for two or more oscillating surfaces. In order to calculate interfering aerodynamic forces, theoretical procedures were developed which may be divided into lifting surface theories and double lattice methods. Measurements of unsteady pressure distributions on a variable wing-tail configuration, were compared with the results of the lifting surface theory. Author

02 AIRCRAFT

Includes fixed-wing airplanes, helicopters, gliders, balloons, ornithopters, etc; and specific types of complete aircraft (e.g., ground effect machines, STOL and VTOL); flight tests, operating problems (e.g., sonic boom), safety and safety devices, economics, and stability and control. For basic research see 01 Aerodynamics. For related information see also 31 Space Vehicles; and 32 Structural Mechanics.

N71-20051# Advisory Group for Aerospace Research and Development, Paris (France)

ASSESSMENT OF LIFT AUGMENTATION DEVICES

Feb 1971 284 p refs Presented at the Lecture Series, Rhode-Saint-Genese, Belgium, 20 24 Apr 1970. Sponsored by AGARD and von Karman Inst

(AGARD-LS-43-71) Avail NTIS

CONTENTS

N71-20052# Hawker Siddeley Aviation, Ltd, Hatfield (England) Aerodynamic Dept

AERODYNAMICS OF MECHANICAL HIGH LIFT DEVICES

D M McRae *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 23 p refs (See N71-20051 09-02)

Avail NTIS

The purpose is to describe in general terms the stalling of conventional airfoils and the effects of mechanical high lift devices thereon. The factors affecting maximum lift coefficient are discussed in the context of estimation methods. Drag is also discussed Author

N71-20053# Technische Hochschule Carolo Wilhelmina, Brunswick (West Germany) Inst fur Stromungsmechanik

AERODYNAMICS OF PNEUMATIC HIGH LIFT DEVICES

J von der Decken *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 36 p refs (See N71-20051 09-02)

Avail NTIS

An introductory survey of pneumatic boundary layer and circulation control schemes for increasing maximum lift is given. The physical background of boundary layer control by suction and blowing, and of supercirculation and slipstream effects, is described, also the aerodynamic efficiency of the different devices is estimated by theoretical approaches. Finally, practical applications and performance evaluation of pneumatic devices are discussed Author

N71-20054# Office National d'Etudes et de Recherches Aerospatiales, Paris (France) Dept des Etudes de Synthese

AERODYNAMICS OF VARIABLE SWEEP

Ph. Poisson-Quinton *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 19 p refs (See N71-20051 09-02)

Avail NTIS

Aerodynamic problems in the design of variable sweep aircraft are discussed. Selection of pivot location is reviewed, as well as investigations of high lift devices, wing camber, and longitudinal instability near the stall on variable sweep configurations. Application of this configuration to reusable spacecraft is mentioned E.C

N71-20055# von Karman Inst for Fluid Dynamics, Rhode Saint-Genese (Belgium)

FUNDAMENTAL ASPECTS OF FLOW SEPARATION UNDER HIGH LIFT CONDITIONS

H P Horton *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 19 p refs (See N71-20051 09-02)

Avail NTIS

A qualitative description is presented of separation problems covering two dimensional laminar and turbulent separation concepts, separated flow on single two dimensional airfoils, boundary layer separation bubbles, separated flow on multi-airfoil systems (wake and boundary layer mixing) and three dimensional separated flow. The possibility of applying theoretical techniques to the prediction of the maximum lift and drag of an airfoil is briefly discussed E C

N71-20056# National Lucht En Ruimtevaartlaboratorium, Amsterdam (Netherlands)

SOME NOTES ON TWO DIMENSIONAL HIGH LIFT TEST IN WIND TUNNELS

B van den Berg *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 18 p refs (See N71-20051 09-02)

Avail NTIS

Problems associated with two dimensional high lift tests

are discussed in terms of the test setup in the wind tunnel the design of the models, and the methods to determine the forces on the model Tunnel wall interference effects are also discussed These include the effect of the constraint which the tunnel walls impose on the flow as well as the danger of boundary layer separations on the tunnel walls The necessity of boundary layer control at the model tunnel wall junctions is demonstrated Author

N71-20057# British Aircraft Corp, Warton (England) Wind Tunnel Dept

MODEL TESTING REQUIREMENTS AND TECHNIQUES FOR HIGH LIFT SCHEMES: THREE DIMENSIONAL ASPECTS

C Russell *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 22 p refs (See N71-20051 09-02)

Avail NTIS

The subject of three-dimensional high lift model testing is dealt with from the point of view of the development of a specific full-size project Various topics and problems are dealt with in approximately the order in which they would normally arise from initial concept to data presentation Author

N71-20058# Boeing Co Seattle Wash

ANALYSIS OF TRANSPORT APPLICATIONS FOR HIGH LIFT SCHEMES

L B Gratzer *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 23 p refs (See N71-20051 09-02)

Avail NTIS

The way in which the design tradeoff process affects airplane economics is illustrated in relation to the impact of high lift system design on the final configuration selection An assessment of representative high lift concepts, including boundary layer control, is given in terms of low-speed performance potential For long-range transport airplanes operating from long runways, it is shown that well-designed mechanical flap systems are generally competitive with more sophisticated concepts involving blowing or suction boundary layer control (BLC). However, recent progress in high lift technology indicates that significant performance gains for long-range airplanes may be possible using BLC techniques The gains for airplanes designed to operate from shorter fields appear attractive and achievable with today's technology For STOL airplanes the use of BLC to provide high wing lift together with direct lift from the engines, or a more highly integrated form of lift augmentation such as the jet flap, is mandatory The interaction between high lift system design and problems involving the stability and control characteristics of the airplane are considered Author

N71-20059# Breguet-Aviation, Velizy (France) Div Aerodynamique

ANALYSIS OF COMBAT AIRCRAFT APPLICATIONS FOR LIFT AUGMENTATION DEVICES

R Tesseire *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 21 p (See N71-20051 09-02)

Avail NTIS

Problems associated with the design of high lift systems for combat aircraft are reviewed Performance and flying qualities are considered Low level high speed flying requires small wing thickness to chord ratio (about 5 to 7%), high sweep angle (35 to 45 degs), small aspect-ratio (3 to 4) and high wing loadings (about 400 to 600 kg per sq meter) With such a wing, it is difficult to provide good take-off and landing performance for short field operation while maintaining good flying qualities at low speeds Effective high lift devices are needed to achieve the low stalling speeds required for short takeoff and landing distances and their design must provide a satisfactory level of control in the low speed flight range The review is intended to clarify the problems encountered in achieving these aims and to indicate ways of solving them Author

N71-20060# Aeroplane and Armament Experimental Establishment, Boscombe Down (England) Performance Div

FLIGHT TESTING MILITARY TRANSPORT AIRCRAFT FOR CLEARANCE IN THE STOL ROLE

K P Eyre *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 24 p ref (See N71-20051 09-02)

Avail NTIS

The types of tests which are likely to be required to clear an aircraft from handling and performance aspects for military STOL applications are discussed Tests made to clear the Andover C Mk 1 are given as an example No special consideration is given to particular high lift devices each of which may of course introduce individual problems However, it is considered that in the case of STOL aircraft generally the problem of variability in behavior may require more than usual attention due to the rapid maneuvers and short distances involved with considerable dependence on pilot technique Author

N71-20061# Rolls-Royce, Ltd, Bristol (England) Bristol Engine Div

LIFT AUGMENTATION DEVICES AND THEIR EFFECT ON THE ENGINE PART 1: INTERFACE PROBLEMS BETWEEN ENGINE AND AIRFRAME

J A Hooper *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 18 p (See N71-20051 09-02)

Avail NTIS

Interface problems between engine and airframe associated with the achievement of short field performance are described Civil and military aircraft are treated with the main emphasis on civil STOL A range of possible lift augmentation devices is considered, and their effect on engine design is shown The associated problems of noise and performance are also considered Optimum engine designs and their particular characteristics for various systems are described Author

N71-20062# Rolls-Royce, Ltd, Bristol (England) Bristol Engine Div

LIFT AUGMENTATION DEVICES AND THEIR EFFECT ON THE ENGINE PART 2: THERMODYNAMIC PROBLEMS AND SOME POSSIBLE SOLUTIONS

E A White and H C Hillier *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 13 p (See N71-20051 09-02)

Avail NTIS

The effects of the previously established design criteria on the thermodynamics of the engines for STOL applications are discussed Several possible engine solutions with their associated advantages and disadvantages are described Author

N71-20063# Lockheed Georgia Co Marietta

OPTIMISING THE PROPULSIVE LIFT SYSTEM FOR TURBOFAN STOL AIRCRAFT CONSIDERING COST EFFECTIVENESS

H T Bowling *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 14 p (See N71-20051 09-02)

Avail NTIS

The results are presented of a comparison of three STOL high lift concepts which have been integrated with bypass ratio turbofan engines Transport aircraft configurations optimized using these concepts are compared along with significant characteristics of each system The purpose of this comparison was to provide possible insight for future studies and testing None of these systems were subjected to a highly detailed analysis and do not represent completely optimized concepts Every effort was made to make the comparison as consistent as possible A secondary purpose is the discussion and demonstration of a study methodology which was developed to integrate cost effectiveness into the early technical development of new airplane concepts This methodology is primarily applied to a military STOL development program However some examples are shown of considerations of commercial cost effectiveness Author

N71-20064# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

A NEW TECHNIQUE FOR AEROFOIL LEADING EDGE STUDIES

J Monnerie *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 5 p ref (See N71-20051 09-02)

Avail NTIS

Illustrations are given from an investigation of flow separation bubbles which develop near an airfoil leading edge. These include a drawing of the airfoil profile, a velocity diagram for a profile with a Handley Page slat, a plot of the similarity between the flow on two models, surface flow visualization near the leading edge, boundary layer curves in the bubble region, and water tunnel model visualization data E.C.

N71-20065# Royal Aircraft Establishment, Farnborough (England)

SOME COMMENTS ON CHARACTERISTICS OF HIGH LIFT WINGS

D N Foster *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 5 p refs (See N71-20051 09-02)

Avail NTIS

Wind tunnel tests, under as near to two dimensional conditions as possible, were carried out on a wing section with plain leading and trailing edge flaps having boundary layer control by blowing at the flap knees. A range of flap deflections were tested; results are presented for the condition with no leading edge flap deflection and with the trailing edge flap deflection 20 deg. Results suggest that the inviscid lift is achievable with a momentum coefficient which is dependent on the angle of incidence (or the lift), that under these conditions a pressure distribution will be measured which is very similar to the inviscid predictions, and that sensibly zero drag will result. Drag with high lift devices is also discussed Author

N71-20066# Hawker Siddeley Aviation, Ltd., Hatfield (England)

THE HUNTING H-126 JET FLAP RESEARCH AIRCRAFT

K D Harris *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 7 p refs (See N71-20051 09-02)

Avail NTIS

The jet flap principle is reviewed, as well as the development of a piloted research aircraft to test the principle. Aircraft thrust losses, stability and control problems, and stalling characteristics are discussed E.C.

N71-20067# Canadair, Ltd., Montreal (Quebec)

AERODYNAMIC RESEARCH ON HIGH LIFT SYSTEMS

Fotis Mavriplis *In* AGARD Assessment of Lift Augmentation Devices Feb 1971 13 p refs (See N71-20051 09-02)

Avail NTIS

Aspects of two dimensional flow research on high lift systems are discussed. A theoretical method is described for calculating two dimensional potential flow about multi-element high lift airfoils. The method is based on the distribution of vorticity on the airfoil contour. A wall blowing technique is also described which was developed for testing effectively complex high lift models in the wind tunnel. It was used to study the effect of leading edge and trailing edge devices on the aerodynamic characteristics of a 17% and a 10% thick airfoil. Finally, comparisons of calculated and experimental data obtained on some of the complex configurations tested are presented to demonstrate the usefulness of the methods described. Author

N71-23410# Advisory Group for Aerospace Research and Development, Paris (France)

LESSONS WITH EMPHASIS ON FLIGHT MECHANICS FROM OPERATING EXPERIENCE, INCIDENTS AND ACCIDENTS

Mar 1971 301 p refs Presented at the 37th Meeting of the Flight Mech Panel of AGARD, Baden-Baden, 20 23 Oct 1970 (AGARD-CP-76-71) Avail NTIS HC $6.00/MF $0.95

Detailed accident and incident investigations, flight control systems developments and operational performance recordings are used to optimize aircraft flight mechanical parameters. Considerable emphasis is placed on human factors engineering for aircraft safety requirements. For individual titles see N71-23411 through N71-23431

N71-23411# Air Registration Board, London (England)

A BRIEF REVIEW OF SOME SAFETY STUDIES BASED ON OPERATIONAL FLIGHT RECORDING

J. C. Chaplin *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar 1971 26 p refs (See N71-23410 12-02)

Avail NTIS HC $6.00/MF $0.95

In order that advances in aviation safety may continue to be made without unnecessarily adding to cost, it is essential to be able to study the effectiveness of current regulations to determine whether or not they are acting in the manner expected. Methods which have been developed to abstract and examine data of safety interest are outlined. The fields of operations and airworthiness are both considered and the relative places of statistical data on the one hand and the more detailed study of isolated events are discussed. Examples are given of some of the results which have been obtained. The importance of the close links which have been developed with the operator is emphasized Author

N71-23412# National Aerospace Lab., Amsterdam (Netherlands)

OPERATIONAL FLIGHT RECORDING AND ITS IMPACT ON FLIGHT SAFETY AND AIRCRAFT DESIGN

T Van Oosterom *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar 1971 19 p refs (See N71-23410 12-02)

Avail NTIS HC $6.00/MF $0.95

Flight operational experience and results from incident and accident analyses are important sources of basic information for improving flight safety and aircraft design. These sources can be effectively explored by in-flight recording of data, which define the flight condition, the navigational environment and the technical functioning of the aircraft. Present aircraft integrated data systems (AIDS) provide an extensive data acquisition capability and allow for automatic data processing. The main technical features of these systems and the relevant data processing equipment are reviewed from a users' point of view. A survey is given of present and possible future applications of AIDS with emphasis on flight safety and aircraft design data recording. Some specific examples are discussed which illustrate the usefulness of flight recording. Author

N71-23413# General Dynamics/Fort Worth, Tex

PROVING THE OPERATIONAL CAPABILITY OF A HIGH PERFORMANCE FLIGHT CONTROL SYSTEM

E C Livingston, Jr *In* AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents Mar 1971 12 p (See N71-23410 12-02)

Avail NTIS HC $6.00/MF $0.95

Two generalized approaches to the development and proof of a high performance flight control system are examined. The first approach is conventional in that no more than minimal simulation is utilized to confirm the system analysis and design. In the second approach, extensive use is made of complete closed-loop simulation, including an accurate dynamic model of the airframe, to confirm analysis and design. Examples encountered in the utilization of these two approaches are provided in order to illustrate the benefits of one approach over the other. Experience gained from the utilization of both of these approaches has shown the latter to be the best. The extensive use of flight simulators and an airframe test stand assures that the system will meet requirements after minimal retrofit and flight test Author

N71-23414# Smiths Industries. Ltd., London (England)
THE OPERATIONAL PROVING OF AUTOMATIC FLIGHT CONTROL SYSTEMS IN THE APPROACH AND LANDING PHASE
R H Ashforth *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience. Incident and Accidents Mar 1971 10 p (See N71-23410 12-02)
Avail. NTIS HC $6.00/MF $0 95

The Hawker Siddeley Trident aircraft equipped with a flight control system that covers both automatic approaches and automatic landings is studied. The flight control system comprises the SEP 5 autopilot which is triplex in the pitch and roll axis and duplex in yaw. The lessons learnt during the flight trails and also as a result of the service experience are discussed Changes made to the original design as a result of this experience, applicable to the approach and landing phase, are described in relation to the different levels of clearance The second part of the paper covers the in-service recording and statistical proving of the automatic landing system. Author

N71-23415# Messerschmitt-Boelkow-Blohm G m b H , Munich (West Germany)
OPERATIONAL PROVING OF AUTOMATIC FLIGHT CONTROL SYSTEMS FOR V/STOL FIGHTER AIRCRAFT
G Kissal and H Schmidtlein (Vereinigte Flugtech. Werke G m b H , Bremen. West Germany) *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience Incidents and Accidents Mar 1971 26 p refs (See N71-23410 12-02)
Avail NTIS HC $6 00/MF $0 95

Four different types of automatic flight control systems for V/STOL fighter aircraft were flight tested within the past years The VJ 101 C aircraft makes use of pure jet-thrust-modulation control in the thrust sustained flight regime for rolling and pitching and thrust vector control for yawing The VAK 191 flying bedstead uses puff-pipe (bleed air) control with additional thrust augmentation for pitching The main characteristics of the systems are (1) stability augmentation system with high authority superimposed on the mechanical flight control system versus fly by wire system, (2) integrating control system versus proportional system. (3) pure VTOL versus V/STOL capability. (4) pure thrust modulation control versus puff-pipe control. and (5) puff-pipe control by means of fly by wire with mechanical back up With all four systems acceptable handling qualities could be reached but it is shown that. especially in case of thrust modulation where the aircraft has nonlinear characteristics. for large control inputs a nonlinear control system gives higher stability Author

N71-23416# Deputy Chief of Naval Operations (Development) Washington, D C
DESIGN LESSONS LEARNED FROM THE OV-10A BRONCO
Hugo G Sheridan *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience. Incidents and Accidents Mar 1971 13 p (See N71-23410 12-02)
Avail NTIS HC $6 00/MF $0 95

The OV-10A Bronco is one of the aircraft designed specifically for low level counterinsurgency warfare The original design requirements for the aircraft as well as the engineering changes found necessary during the flight test stage are reviewed Use of the Bronco in combat operations in Southeast Asia is summarized including loss and damage rate As a result of these combat operations. conclusions are drawn as to the validity of the original requirements for the OV-10A Design requirements desirable for the next counterinsurgency aircraft in light of the experience in Southeast Asia are recommended Author

N71-23417# Hawker Siddeley Aviation Ltd Woodford (England)
LESSONS FROM OPERATION AND TRIALS OF TWIN TURBO PROP AIRCRAFT ON ROUGH AIRFIELDS
M J Taylor *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience Incidents and Accidents Mar 1971 13 p refs (See N71-23410 12-02)
Avail NTIS HC $6 00/MF $0 95

Trials and operations of a civil twin turboprop airliner and of its military counterpart have taken place over a period of nearly ten years During this time both measured data and operating experience have been accumulated from movements on unprepared airfields In particular the investigation into two landing accidents involving the civil type has led to performance measurements on grass and hard surfaces Information is given on the following (1) undercarriage load measurements. (2) airframe contamination and superficial damage. and (3) aeroplane performance Author

N71-23418*# National Aeronautics and Space Administration, Washington. D C
AVOIDANCE OF AIRCRAFT TRAILING VORTEX HAZARDS
William A McGowan *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience. Incidents and Accidents Mar 1971 23 p refs (See N71-23410 12-02)
(NASA-TM-X-67125) Avail NTIS CSCL 01C

Trailing vortices have been the cause of aircraft accidents Results of accident investigations. theoretical exercises. wind tunnel experiments. and flight tests are used to describe the formation and severity of trailing vortices and the spatial extent of their influence, including factors governing persistence This information is then used to outline procedures for ready application by pilots. tower operators. and those concerned with the flow of traffic during tactical operations The procedures provide the necessary appreciation of the physical attributes of trailing vortices. the potential hazards involved when encountering them. and how best to avoid the dangerous portions of the wake during flight operations Schemes under investigation to monitor remotely both the trailing vortex location and intensity in the airport area and to prohibit formation of high intensity vortices. through aircraft design are discussed Author

N71-23419# Mississippi State Univ , State College Dept of Aerophysics and Aerospace Engineering
THE HANDLING QUALITIES REQUIRED FOR SAFE OPERATION OF SINGLE ENGINE BOUNDARY LAYER CONTROLLED AIRCRAFT IN THE STOL MODE
S C Roberts *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience. Incidents and Accidents Mar 1971 16 p refs (See N71-23410 12-02)
Avail NTIS HC $6 00/MF $0 95

Operations of single engine. boundary layer control. STOL aircrafts since 1958 are reported The vehicles have been the high lift. super cub L-21. the modified Cessna L-19. the XAZ-1. and the XV-11A with wing loadings ranging from 13 lb/sq ft to 28 lb/sq ft All of these aircraft had a distributed suction boundary layer control system for lift augmentation and XAZ-1 and the XV-11A also had shrouded propellers for static thrust augmentation The performance stability and control, and handling qualities of these aircraft have been evaluated and considerable experience gained in the operational aspects of such STOL aircraft with regard to the handling qualities required for safe operation in the STOL mode Author

N71-23420# Breguet Aviation Velizy (France)
ESTABLISHING SAFETY MARGINS FOR THE TAKE OFF AND APPROACH OF THE BREGUET 941 [ETABLISSEMENT DES MARGES DE SECURITE AU DECOLLAGE ET A L'ATTERRISSAGE POUR LE BREGUET 941]
J Bastidon *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience Incidents and Accidents Mar 1971 9 p (See N71 23410 12-02)
Avail NTIS HC $6 00/MF $0 95

The safety margins to be considered are of the two following types (1) speed margins (takeoff and approach speed). and (2) fieldlength margins These two margins are examined and discussed considering the BR 941 Determination of these margins is based

on theoretical considerations, flight measurements and operational test results. Allowance is also made for discussions determining special conditions for civil airworthiness of this airplane Author

N71-23421# Naval Air Systems Command, Washington, D.C.
LOW ALTITUDE HIGH SPEED FLIGHT EXPERIENCE
Ralph C. A'Harrah *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar. 1971 13 p refs (See N71-23410 12-02)
Avail NTIS HC $6 00/MF $0 95

An extensive flight test evaluation of the operational capabilities of contemporary military aircraft in performing low altitude missions is reported. The particular test phase being reviewed, namely the visual target acquisition test, involved 8 aircraft and 200 pilots making more than 400 low altitude sorties. Assigned penetration speeds ranged from 175 to 550 Knots. Two altitude corridors were assigned minimum safe altitude to 400 feet and 500 to 900 feet above the terrain Author

N71-23422# Ecole Nationale Superieure de l'Aeronautique, Toulouse (France)
INFLUENCE OF SIMPLE AERODYNAMIC MODIFICATIONS ON THE PERFORMANCE OF AN AIRCRAFT [INFLUENCE DE MODIFICATIONS AERODYNAMIQUES SIMPLES SUR LE COMPORTEMENT D'UN AVION]
J E Forestier *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience Incidents and Accidents Mar 1971 12 p (See N71-23410 12-02)
Avail NTIS HC $6 00/MF $0 95

Described are modifications made on prototype Vautour aircrafts during their development phase. Principle difficulties encountered were lateral control and beyond Mach 0 93 longitudinal control characteristics. Adjustments of the turbulence generator positions on the outer airfoils just before the wing tip, and modifications in the chamber of the wing leading edge provided the desired performance improvements Transl by G G

N71-23423# National Aero- and Astronautical Research Inst., Amsterdam (Netherlands)
MAN/MACHINE COMBINATION IN THE LIGHT OF SAFETY REQUIREMENTS
F W L Herckenrath J J P Moelker, and C M Ramsey *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar 1971 10 p refs (See N71-23410 12-02)
Avail NTIS HC $6 00/MF $0 95

A description is given of a few limiting factors in man and their bearing upon aircraft design. Examples are given of limitations in attention, perception, learning, memory and intelligence, and decision making. Present design deficiencies are considered in the light of crew training and procedures. It is stressed that from the earliest conception of a design close cooperation between designers, safety organisations and prospective operators is of vital importance to assure safety in aerospace operations Author

N71-23424# National Aeronautical Establishment, Ottawa (Ontario)
REVIEW OF SEVERAL FACTORS RELEVANT TO JET UPSETS
B Caiger *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar 1971 11 p refs (See N71-23410 12-02)
Avail NTIS HC $6 00/MF $0 95

Various contributory factors to jet upsets are reviewed covering instrument or control system failures and severe turbulence encounters. Related problems of pilot disorientation are discussed. The need for detailed analyses of upsets is emphasized. It is concluded that well designed autopilot systems may provide more effective control in severe turbulence encounters than the human pilot, but that suppression of primary structural modes and the use of head-up displays are still desirable to alleviate the pilot's difficulties. Author

N71-23425# Boeing Co., Seattle, Wash. Commercial Airplane Group
APPROACH PATH CONTROL FOR REDUCED NOISE AND IMPROVED TRAFFIC CAPACITY
C. R. Clifford *In* AGARD Lessons with Emphasis and Flight Mech. from Operating Experience Incidents and Accidents Mar 1971 22 p refs (See N71-23410 12-02)
Avail NTIS HC $6.00/MF $0 95

Final approach control for transport aircraft consists primarily in aerodynamic performance during cruise. The specific objectives defined for the Boeing 727 and 737 in this respect, and the boundary layer control research with the 707 prototype, are outlined, together with results achieved. Steep angle, decelerating, and curving approaches have been considered singly and in combination. A simple speed control for decelerating approach on the normal glidepath angle is under development for the 747 and research activities include extending the capability of high quality area navigation equipment to control of flightpath, speed and configuration on final approach so as to minimize noise. Described are the operational characteristics of the airborne system for terminal path guidance on reduced noise trajectories, including the system configuration, functions of key elements, redundancy requirements, control law aspects, and cockpit displays Author

N71-23426# National Aeronautics and Space Council, Washington, D C
A REVIEW OF V/STOL AIRCRAFT ACCIDENTS IN THE US
John H Enders and William E Thurman *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents and Accidents Mar 1971 14 p refs (See N71-23410 12-02)
Avail NTIS HC $6 00/MF $0 95

V/STOL research and development aircraft accidents have occurred for the same major reasons and over the same operational phase spectrum as have accidents to conventional aircraft. Excluding hover and transition phases from the operational phases, a pattern of accident distribution of V/STOL aircraft is similar to that for conventional aircraft - about 55-60% during landing, about 20% in cruise, and about 20% during takeoff. The pattern of accidents suggests no clearly dominant remedial action to reduce these accidents across-the-board, but increased attention in each of the cause factor areas will effect an improvement. Nearly every accident investigation prompted changes in either design, methods of operation, management structure, pilot training methods, or maintenance procedures Author

N71-23427# Ministry of Defence, London (England)
V/STOL IN THE ROYAL AIR FORCE: SOME LESSONS FROM THE FIRST 18 MONTHS
R G Lofting *In* AGARD Lessons with Emphasis on Flight Mech from Operating Experience, Incidents, and Accidents Mar 1971 4 p (See N71-23410 12-02)
Avail NTIS HC $6 00/MF $0 95

Some 18 months of V/STOL operations with the Harrier ground attack and reconnaissance aircraft have been completed and the aircraft's flight safety record during this period is discussed. The record has been encouragingly good, taking into consideration the novel problems of V/STOL operation and field covered by the complete Harrier flight safety record is not a large one. Selected are the following four topics from the Harrier flight safety record which lie reasonable close to flight mechanics (1) stability and control, (2) exhaust gas reingestion (3) ejection facilities and (4) control system Author

N71-23428# Messerschmitt-Boelkow G.m.b.H. Munich (West Germany).
V/STOL ACCIDENTS OR INCIDENTS
O. Richarz *In* AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents Mar 1971 10 p (See N71-23410 12-02)
Avail. NTIS HC$6.00/MF$0.95

Performance tests on two models of the VJ 101C VTOL high performance aircraft are reported and observed accidents connected with flight mechanical aspects are analyzed. Four out of the five accidents reported had something to do with hot gases and recirculation. A great deal of the recirculation problems experienced were directly connected to the triangular arrangement of the aircraft's 6 engines. G.G.

N71-23429# Sud-Aviation, Toulouse (France).
ALL WEATHER SUD/LEAR LANDING SYSTEM INSTALLED ON THE CARAVELLE [SYSTEME D'ATTERRISSAGE TOUS TEMPS SUD/LEAR INSTALLE SUR CARAVELLE]
G. Payeur *In* AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents Mar 1971 10 p (See N71-23410 12-02)
Avail: NTIS HC$6.00/MF$0.95

Experience with the all weather SUD/LEAR landing system confirms its reliability in phase 3a automatic approach and landing requirements. The system encorporates a flash warning signal on the panel in front of the flight captain that combines all essential warnings relating to aircraft flight control and integrates in particular the following warnings: (1) HZ-4 and MR-4 indicator flags; (2) beam error detector warnings, (3) autopilot warnings, and (4) altituue error warnings transmitted by the radio altimeter AF-and servo-mechanism unit. The fact that the warnings are combined in a single flash enables the flight captain to continue outside the aircraft and yet perceive within his immediate field of vision a possible malfunction flash signal, he can make a decision (down to 50 ft) to continue the approach or to initiate go-around. Transl. by G.G.

N71-23430# Army Aviation Systems Command, St. Louis, Mo.
PROBLEMS ENCOUNTERED IN NAP OF THE EARTH FLYING AND THEIR EFFECT ON AIRCRAFT DESIGN MISSION PERFORMANCE
Lawrence R. Dewey, Jr *In* AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents Mar 1971 5 p refs (See N71-23410 12-02)
Avail: NTIS HC$6.00/MF$0.95

Reviewed are some of the design problems that are accentuated by tactical helicopter maneuvering close to ground. Considered are aerodynamic coupling effects that cause the aircraft to roll during climb with sudden forward pitching for a gun run on target, and dynamic structural aircraft vibrations during low level high speed terrain avoidance maneuvers. Proposed safety measures include an automatic information and warning system for the pilot and safety margins that realistically encompass fatigue dynamics inherent in close to ground operations. G.G.

N71-23431# Ministry of Technology, London (England).
WEATHER AS A FACTOR IN FATAL ACCIDENTS INVOLVING CIVIL TRANSPORT AIRCRAFT
J. Burnham *In* AGARD Lessons with Emphasis on Flight Mech. from Operating Experience, Incidents and Accidents Mar 1971 21 p refs (See N71-23410 12-02)
Avail. NTIS HC$6.00/MF$0.95

An analysis is given of the importance of weather in fatal accidents involving civil transport category aircraft during the period 1946-69. Out of a total of 1,433 accidents involving 25,801 fatalities, weather is known to have been a factor in 318 accidents involving 6,778 fatalities, and may have been involved in others. The average of 13 accidents per year in which weather was involved comprise about 10 per year in poor visibility, 2 per year due to gusts and 1 per year due to icing and other weather hazards. The only type of weather accident which has increased in frequency in recent years is that of approach and landing in poor visibility. Author

N71-25080# Advisory Group for Aerospace Research and Development, Paris (France).
EXTREME VALUE ANALYSIS AND ITS APPLICATION TO c.g. VERTICAL ACCELERATIONS MEASURED ON TRANSPORT AIRPLANES OF TYPE C-130
Otto Buxbaum (Lab. fuer Betriebsfestigkeit) Mar. 1971 31 p refs Presented at 31st Meeting of the Panel on Environ. Statist. Data of AGARD, Tonsberg, Norway, 1-6 Nov. 1970
(AGARD-R-579-71) Avail. NTIS

The interpretation of cumulative frequency distributions of measured flight loads can be increased significantly by an additional extreme value analysis. This method not only leads to a higher reliability in fatigue design but may be used also for a prediction of extreme loading conditions and for a description of the effect of airplane and flight parameters on loads, as is demonstrated for c.g. vertical accelerations and gust velocities measured on airplanes of type C-130. Author

N72-11915# Advisory Group for Aerospace Research and Development, Paris (France).
HELICOPTER GUIDANCE AND CONTROL SYSTEMS
Sep 1971 261 p refs Partly in ENGLISH and partly in FRENCH Presented at the 12th Meeting of the Guidance and Control Panel of AGARD, Konstanz, West Germany, 7-9 Jun 1971
(AGARD-CP-86-71) Avail. NTIS

Papers on military helicopter technology are presented. The topics covered include helicopter requirements, system operation and integration, subsystems, advanced developments, and test results and operational experience. For individual titles, see N72-11916 through N72-11939.

N72-11916# Defense Dept., Washington, D.C.
UNITED STATES ARMY HELICOPTER EXPERIENCES AND FUTURE REQUIREMENTS
Conrad L. Stansberry *In* AGARD Helicopter Guidance and Control Systems Sep 1971 6 p (See N72-11915 03-02)
Avail: NTIS

The U.S. Army has found the helicopter to be an extremely versatile vehicle in performing all functions of combat. It has been integrated into organizations throughout the Army force structure. The concepts of airmobility have been validated during combat operations in a counterinsurgency environment in Vietnam. At this time, the U.S. Army is in a period of transition requiring an assessment of the applicability of the airmobile concept in the mid and high intensity warfare environment. To improve the existing capability, new helicopters and evaluations of different types of units with organic airmobile elements to optimize the effectiveness of our combat units must be developed. It is expected that the concepts of airmobility warfare brought to fruition with the advent of the helicopter and applied so successfully in Vietnam can be applied with equal success on other battlefields in other areas in the future. Author

N72-11917# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
OPTIMIZATION OF AUTOMATIC FLIGHT CONTROL CONCEPTS FOR LIGHT HELICOPTERS WITH ALL WEATHER CAPABILITY
H. Koenig and H. Schmitt *In* AGARD Helicopter Guidance and Control Systems Sep 1971 13 p refs (See N72-11915 03-02)
Avail. NTIS

All-weather equipment of minimum complexity for light helicopters is presented. The criteria for its selection include

mission performance requirements as well as consideration of weight, complexity and cost. The special features of a helicopter with hingeless rotor are discussed. The flight control system being developed is shown by a step-by-step process up to an optimal equipment for civilian and military application in all-weather flight. This report presents the validation of flight control systems of SAS and ASE performance level. Successful flight tests of the Ferranti FAS.2 and the BSW-FRG 14 flight control equipment have been conducted on the helicopter MBB-BO 105. Good agreement has been found between theoretical and simulation studies. The systems can be used for many important military purposes. Author

N72-11918# Service Technique Aeronautique, Paris (France)
FLIGHT SAFETY WITH AUTOMATIC CONTROL: REQUIREMENTS AND IMPLEMENTATION [LA SECURITE DU VOL EN PILOTAGE AUTOMATIQUE EXIGENCES ET REALISATIONS]
A. Guibaud and C. Autechaud *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 6 p In FRENCH (See N72-11915 03-02)
Avail: NTIS

The breakdown of automatic pilots or auxiliary stabilization systems may have grave consequences for helicopter flight, since these aircraft often operate at low altitudes. Safety requirements constitute one part of a theoretical study of breakdowns. requirement implementation and testing were also studied. A probability analysis of simple and double breakdowns was undertaken. In the case of active breakdown of the automatic pilot, it is necessary to limit the rapid evolution of the apparatus and thus to increase the time allowed to the pilot to react and resume manual flight control. Surveillance devices are necessary on the automatic pilot in order to detect active breakdown and to rapidly suppress the erroneous command. Such compatibility and thereshold devices are available on the Puma and Alouette 3 aircraft. Finally, surveillance of the flight control chain, from detectors to servo-command, can be done internal organization of the automatic pilot, extending the possibilities for surveillance devices without increasing cost. Transl. by K.P.D.

N72-11919# Royal Aircraft Establishment, Farnborough (England)
THE IMPLICATIONS OF OPERATING HELICOPTERS IN POOR VISIBILITY
J. E. Nethaway *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 20 p refs (See N72-11915 03-02)
Avail: NTIS

A method of weather minima calculation is proposed for small sites and is extended to allow an estimate to be made of the instrument or automatic approach performance requirements if the weather minima are to be achieved. As an example of the estimation technique an assumption is made of a 6 deg approach path coupled with a 60 kn (111 km/h) approach speed and it is suggested that 120 ft/700 yd (36m/640m) weather minima should be attainable. The equipment requirements necessary to achieve the weather minima are considered and possible developments for the future are discussed. The future developments could include improved displays based on cathode ray tubes, and also various levels of automatic flight path control. A radio/radar guidance aid is required and the overlap between it and the visual guidance system is discussed. The approach and landing system described implies a weight penalty, the extent of which depends on the severity of the weather to be overcome. With this in mind a tentative estimate is made of the equipment weight which may be necessary to achieve various weather minima. Finally, a study has been made of the statistical occurrence of low visibility in the UK from which it has been deduced that, for the approach conditions assumed, a helicopter should be able to complete approaches to land on about 98% of occasions in the year. Author

N72-11920# Air Force Systems Command, Wright-Patterson AFB, Ohio. Air Force Flight Dynamics Lab.
PROGRESS OF THE USAF INFLIGHT PROGRAM: LOW SPEED CONTROL TO LANDING ON INSTRUMENT IN HELICOPTERS
Charles A. Scolatti *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 15 p refs (See N72-11915 03-02)
Avail: NTIS

A functional flight control-display system is described which provides the small and medium sized helicopter a manual-on-instrument capability from take-off to landing. The display solution is based upon extending the capability of the flight director as it is employed today in helicopters for flying fixed wing type profiles to encompass the unique portion of the low speed regime. With respect to automatics, pilot workload has been reduced and control maneuverability enhanced by introducing innovations to the design of stability augmentation systems in the yaw and collective channels. The flight control-display system was developed using beam guidance in anticipation of the upcoming guidance system proposed by the SC-117 Committee. Testing of the system elements is complete. Evaluation of the synthesized system will be completed by the end of the year. Work is beginning on having user command personnel test the system in its applied form on two UH-1N helicopters at the USAF Instrument Pilot Instructors School. Author

N72-11921# Ambac Industries, Inc., Garden City, N.Y. Arma Div.
AN OPTIMUM MILITARY HELCIOPTER NAVIGATION SYSTEM
Marvin Taylor *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 11 p refs (See N72-11915 03-02)
Avail: NTIS

A low-cost, all-weather, self-contained navigation system was studied in order to fully exploit the many military capabilities of helicopters. Inertial, Doppler-Magnetic, and Doppler-Gyroscopic Navigation systems are analyzed to determine parametric requirements (such as gyro drift, torque scaling, and computer requirements) as a function of navigation accuracy. A study of these alternate candidate systems indicates an optimum approach is the combination of Doppler velocity with an accurate heading indicator utilizing low drift gyroscopes that can rapidly gyro-compass to true North during ground alignment. For subsonic application less precise gyro drift is required with this approach than for an equivalent all-inertial system. The various system configurations are functionally defined and cost vs performance analysis using typical parameters is performed for the alternate candidate systems. Author

N72-11922# Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany)
SOME PROBLEMS IN THE DEVELOPMENT OF AN AUTOMATIC FLIGHT CONTROL SYSTEM FOR LIGHT HELICOPTERS
W. Wellern *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 15 p refs (See N72-11915 03-02)
Avail: NTIS

Some of the problems and their solution are discussed arising in the development of an automatic flight control system for light helicopters. The control system is the FRG 14/Stab. The cross coupling between the axes makes it essential to regard the helicopter control as multiloop control and to take account of all six degrees of freedom of the vehicle. These investigations were done with the aid of a program drawn up recently for analysis applied first to a light helicopter which is equipped with a hingeless rotor (BO 105). This type of rotor shows very high control effectiveness and very fast reactions to control inputs. Thus it seems to be necessary to include the nonlinearities of actuators and hydraulic booster in the investigation and to perform a simulation on the analog computer. Here the problem of limit cycles due to backlash arises. The limit cycles are reduced by ... of special nonlinear networks so that they are no longer perceived by passengers. Development of the FRG 14 System was continued by hardware simulation and concluded with good results in flight tests. Author

N72-11923# Siemens A.G., Munich (West Germany)
DIFFERENCES AND COMMONALITIES IN HELICOPTER

AND FIXED WING DOPPLER SENSOR TECHNOLOGY
K Maerz *In* AGARD Helicopter Guidance and Control Systems Sep 1971 5 p refs (See N72-11915 03-02)
Avail NTIS

The possibilities and limitations of rotary and fixed wing compatible Doppler sensor designs are discussed Measurement of velocities near zero at often relatively high values for the drift angle is a requirement for helicopters only For fixed wing aircraft on the other hand operation at high altitudes at high speeds influence antenna and transmitter design. The lower mean speeds in helicopters put more weight on these measurement errors, which are constant relative to velocity, whereas in fixed wing aircraft in most cases measurement errors dominate which are proportional to velocity. In helicopters and VTOL aircraft fixed antenna installation is generally preferred. Whereas the use of noncoherent pulse systems is limited to fixed wing aircraft, continuous wave and FM Doppler sensors are successfully used in helicopter navigation systems Author

N72-11924# Teledyne Systems Co, Northridge, Calif.
AN INTEGRATED LOW ALTITUDE FLIGHT CONTROL SYSTEM FOR HELICOPTERS
James P. Murphy, Herman L Walker, and Lawrence A. Kaufman *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 20 p refs (See N72-11915 03-02)
Avail: NTIS

After a brief introduction that highlights the need for the system and some design philosophies, the basic concepts for low altitude flight are presented indicating the modes of flight employed by IHAS, terrain following (TF), and terrain avoidance (TA) This is followed by a dissertation on the functional approach used to provide the relatively high degree of TF capability required Block diagrams are utilized to identify the system sensors, central computer and output devices, i.e displays and flight controls. Prior to a discussion of the equations solved by the central digital computer the equipment mechanization is briefly described to familiarize the reader with the IHAS equipments A commentary is presented on the setup and results of a simulation of the automatic TF system and is followed by a description and limited listing of results of the IHAS flight test program. It is shown that the high degree of TF capability provided agreed very well with the results predicted by analysis and simulation. Finally, some concluding remarks are provided to identify the significant accomplishments of the IHAS low altitude control system development Author

N72-11925# Singer-Kearfott, Pleasantville, N Y.
OPERATIONAL CONSIDERATIONS AND APPLICATIONS OF THE TALAR(R) 4 LANDING AID TO HELICOPTERS

R. Hohol and J. Taylor *In* AGARD Helicopter Guidance and Control Systems Sep 1971 13 p refs (See N72-11915 03-02)
Avail NTIS

The requirements of helicopter operations are discussed for using the Talar 4 system, currently in operational use by the United States Air Force to provide a portable landing aid for fixed wing tactical transport aircraft. The Talar 4 ground station characteristics are presented with helicopter flight test evaluations in Europe. It is concluded that the Talar 4 system is capable of meeting tactical helicopter operational requirements. F.O.S.

N72-11926# Aeronautical Systems Div., Wright-Patterson AFB, Ohio
AUTOMATIC APPROACH AND HOVER COUPLER FOR HH-53 HELICOPTERS
Robert A. Andes *In* AGARD Helicopter Guidance and Control Systems Sep 1971 7 p refs (See N72 11915 03-02)
Avail NTIS

The Automatic Approach and Hover Coupler which provides the HH-53 rescue helicopter with the capability to automatically transition from forward flight, anywhere within the HH-53 flight envelope, to a hover over flat or rolling terrain, independent of gross weight and center of gravity is discussed The approach coupler design is based on an approach trajectory characterized by a constant longitudinal deceleration of 8 knots/seconds and a constant rate of descent of 300 feet/minute until a groundspeed of 40 knots is reached. At this point the rate of descent is reduced to 100 feet/minute. The hover coupler provides altitude retention within + or - 3 feet and zero knot groundspeed within + or - 1.5 knots of the Doppler radar measured velocity A hover trim control is also provided to permit a limited repositioning of the aircraft by the pilot/copilot/ crewman during the rescue operation The couplers satisfactorily completed environmental qualification tests at Sikorsky Aircraft Company, Stratford, Connecticut, and operational test and evaluation by the Military Airlift Command, Eglin Air Force Base, Florida Author

N72-11927# Army Electronics Command, Fort Monmouth, N.J.
TERRAIN AVOIDANCE RADAR FOR US ARMY
Otto H. Schoenberger *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 14 p refs (See N72-11915 03-02)
Avail NTIS

The objectives and the conduct of the U.S Army's development program are reported for providing a terrain avoidance/terrain following capability for Army rotary-wing aircraft. The over-all program goals are described Control aspects of helicopters were considered in light of TA/TF requirements with an immediate realization of their importance in any TA/TF application. As such, the control system was developed first, including terrain following command computation and coupling provision to the flight control system A unique method of in-flight simulation of terrain and radar sensor was conceived. This airborne terrain and radar simulator allows full in-flight evaluation of the control system, and offers unlimited flexibility as to the type of terrain over which the system is to be tested without subjecting the aircraft and crew to the hazards of testing a control system in close proximity to terrain. A variable parameter terrain avoidance radar is described to replace the terrain and radar simulator after initial evaluation of the control system. The primary objective for this radar was to provide a terrain sensor with technical flexibility sufficient to allow TA/TF performance evaluation over the complete performance spectrum, ranging from simple fixed beam manual terrain following to sophisticated simultaneous terrain following and terrain avoidance, using transverse profile type display and coupling into the flight control system. Technical details of the radar design are given, including selection of the parameters Author

N72-11928# Royal Aircraft Establishment, Farnborough (England).
THE EFFECTS OF SEMIRIGID ROTORS OF HELICOPTER AUTOSTABILISER DESIGN
H. B. Johnson *In* AGARD Helicopter Guidance and Control Systems Sep 1971 13 p refs (See N72-11915 03-02)
Avail NTIS

Theoretical studies carried out into the basic problems posed by 'semi-rigid' rotor designs are described, and the directions in which automatic stabilizers for these aircraft are likely to develop are indicated. Two problems in particular were examined, viz the pitching instability with angle of attack and forward speed, and the interaction between aircraft of motion and those of the rotor dynamics. The latter problem is concerned with the rolling motion termed the 'pendulum' mode resulting primarily from the increased coupling between fuselage and rotor It is shown that a potential resonance between the 'pendulum' mode and the in-plane blade motion exists. Means of avoiding this by suitable design of the autostabilizer are suggested Author

N72-11929# Societe Nationale Industrielle Aerospatiale, Paris (France)
AN AUTONOMOUS NAVIGATION SYSTEM FOR HELICOPTERS [SYSTEME DE NAVIGATION AUTONOME POUR HELICOPTERES]
M Fourcade *In* AGARD Helicopter Guidance and Control Systems Sep 1971 8 p In FRENCH (See N72-11915 03-02)
Avail NTIS

An autonomous navigation system which was developed for the SA-330 helicopter is described A discussion of the components, functions, and essential characteristics of the system is presented. Flight test methods are considered for utilization in performance determination. Transl. by K.P.D.

N72-11930# Elliott Flight Automation, Ltd., Rochester (England). Flight Controls Div.

SOME DESIGN ASPECTS OF THE STABILITY AUGMENTATION SYSTEM FOR THE WG13 RIGID ROTOR HELICOPTER

D. Sweeting *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 12 p (See N72-11915 03-02)

Avail: NTIS

Some features of the AFCS designed for the Anglo-French WG13 rigid rotor helicopter are described and in particular those arising from the concept of a modular multi-role helicopter, designed both for high speed maneuverable flight at low altitudes and for operation in tightly controlled autopilot modes. A brief description of the system configuration including redundancy, safety features, sensors, and actuation system is given together with an indication of system size and weight, and electronics technology employed. The design requirements for the pitch stability augmentation system (SAS) are examined in relation to the conflicting requirements for low SAS authority for safety against the high control gains combined with large attitude changes required for stability and maneuverability. The concept of a collective autostabilizer independent of the pitch SAS is introduced which alleviates these design problems of the pitch channel and reduces considerably the effects of a pitch runaway. The design of the roll SAS channel is similarly influenced by the requirement for stability at high angles of bank during maneuvers while using the minimum of control authority; a type of roll rate demand system designed to operate over a wide range of bank angle is described together with the control system developed for the yaw axis. Author

N72-11931# United Aircraft Corp., Stratford, Conn. Avionics, Control and Support Systems Branch

A FEASIBLE FEEL AUGMENTATION SYSTEM FOR HELICOPTERS

Harold S. Oakes *In* AGARD Helicopter Guidance and Control Systems Sep 1971 7 p (See N72-11915 03-02)

Avail. NTIS

A description and evaluation are given of the feel augmentation system (FAS). The FAS differs from most traditional automatic flight control systems in that, instead of augmenting the pilot's input to the control system by providing swash plate motion to stabilize the helicopter, it introduces only forces on the pilot's hand. If the pilot resists these forces, he then experiences the feel desired for continuing the maneuver he has started. If he does not resist the force, the stick will move and stabilize the aircraft so that it will stay in steady state trimmed flight. An extensive flight evaluation of the system in a CH-53A indicated a significant improvement in the handling qualities of the helicopter at high speeds, and that the aircraft could be maneuvered precisely at all airspeeds, permitting the pilot to use the entire V-N envelope. D.L.G.

N72-11932# Societe Francaise d'Equipments pour la Navigation Aerienne, Neuilly-Sur-Siene (France) Dept. Pilotage Helicoptere

STABILITY AUGMENTATION SYSTEMS (SAS) [LES SYSTEMES D'AUGMENTATION DE STABILITE (SAE)]

Henrot *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 5 p In FRENCH (See N72-11915 03-02)

Avail NTIS

A simple system for increasing helicopter stability is discussed. The components of the calculator and jack are described. Transl. by K.P.D.

N72-11933# Princeton Univ., N.J. Dept. of Aerospace and Mechanical Sciences

HELICOPTER IFR FLIGHT PATH CONTROL SYSTEM

Theodor A. Dukes *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 10 p refs (See N72-11915 03-02) (Contract DA-28-043-AMC-02412(E))

Avail: NTIS

Various aspects of piloted flight path control, including positioning, are discussed according to their significance in making decisions about the structure of the control system. The translational loop requirements, the choice of a nominal error coordinate system, and a discussion of the pilot's role, lead to a control system in which errors and error rates are displayed explicitly and the pilot uses essentially acceleration control in his main effort to control error rates or velocities in three dimensions. An integrated display contains all the information needed for the continuous loop closures. The proposed system is applicable to trajectory control in general so that considerable commonality in flying various tasks can be achieved. Author

N72-11934# Army Electronics Command, Fort Monmouth, N.J. Avionics Lab

PRECISE IFR HOVERING: AN OPERATIONAL NEED AND A FEASIBLE SOLUTION

William P. Keane and R. Joseph Milelli *In* AGARD Helicopter Guidance and Control Systems Sep. 1971 9 p (See N72-11915 03-02)

Avail: NTIS

A man-machine simulation program was conducted which indicates the feasibility of developing an IFR hover capability with state-of-the-art sensors, controls and displays. Display alternatives included a simple hover indicator, a flight director and a fully integrated multi-colored CRT display. Control alternatives for the CH-54 aircraft included the CH-54 ASE and two alternate systems employing load cable information feedback and velocity feedback. IFR hover was shown to be a reasonable task from a pilot workload standpoint. Displays and controls couple strongly in finding the best solution. A wide range of performance was achieved with the best systems providing a hover accuracy of 1-2 feet. All tests were performed under simulated gust conditions. A formal analysis of variance was performed on the data. These results indicate the feasibility of accomplishing more precise construction and logistical tasks by the helicopter in the near future through the use of instrument hover. The unloading of containerized ships by the helicopter is a possible application with both commercial and military advantage. Author

N72-11935# Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany)

ADVANCED DOPPLER INERTIAL NAVIGATION SYSTEM FOR TRANSPORT HELICOPTER

V. Krogmann *In* AGARD Helicopter Guidance and Control Systems Sep 1971 14 p refs (See N72-11915 03-02)

Avail NTIS

Conventional ground and in-air gyrocompassing techniques together with Doppler-inertial navigation are treated briefly. Main attention is paid to optimal ground and in-air alignment and Doppler-inertial-mixing. As far as the optimization is concerned, Kalman filter technique with a ten to fourteen element state vector is compared to a simple digital filter-technique based on recursive or non-recursive least squares. Comparison between the least-square-technique and the Kalman-filter shows that their respective performance is roughly in the same order of magnitude without position fixes. The least-square-technique is recommended because its airborne computer requirements are by far lower than the Kalman-filter loading. This technique, as well as the Kalman-filter has the ability to recover the position error caused by initial misalignment and the performance does not depend on the magnitude of the initial misalignment. The proposed system is based on the least-square technique. Assuming a 2 - 3 minutes ground alignment, the operational sequence for in-air alignment and Doppler-Inertial Navigation is described. The computer loading for both the ground and in-air alignment of this system is considered. Author

N72-11936# Mullard Research Labs., Redhill (England)
DESIGN AND EVALUATION OF A HELICOPTER GUIDANCE AID c21
R N Alcock, D Atter, S J Robinsin, and R P Vincent *In* AGARD Helicopter Guidance and Control Systems Sep 1971 4 p (See N72-11915 03-02)
Avail NTIS

A description of the microwave aircraft digital guidance equipment (MADGE) system is given The system is designed as an approach aid for V/STOL and fixed wing aircraft and is particularly suited for military tactical applications and for use by helicopters A typical MADGE ground installation comprises three man-portable units (1) an azimuth approach angle measuring unit incorporating a transponder and means for encoding azimuth and elevation measurements, (2) an elevation, or glide-slope, angle measuring unit, and (3) an azimuth missed-approach angle measuring unit. In the aircraft there is a control panel, on which the approach data may be set by the pilot, and a transmitter-receiver, with circuits for distance measurement and for decoding the angle information In civil applications the approach path can be pre-set for individual aircraft types One or two monopole aerials, depending on aircraft aerial siting and observation problems, are used to give wide angle coverage D L G

N72-11937# Honeywell, Inc Minneapolis, Minn
FLIGHT TEST OF A HYDROFLUIDIC THREE-AXIS DAMPER ON A HELICOPTER
R A Evans and G W Fosdick *In* AGARD Helicopter Guidance and Control Systems Sep 1971 12 p refs (See N72-11915 03-02)
Avail NTIS

Tests were conducted on a fixed-gain, three-axis hydrofluidic stability augmentation system (FSAS) in a UH-1C helicopter The FSAS used a vortex rate sensor, two or more stages of amplification, and various shaping networks (lag, lag/lead, and high-pass) in each of the three axes, all mechanized with hydrofluidics The system was designed, developed, bench tested and qualified for the environment Reliability testing previously conducted estimated MTBF at 83,000 hours per axis (excluding servoactuator) Flight test results indicate pilot approval, operation over all airspeeds including hover, and excellent handling qualities The FSAS performance was rated as better than that of the mechanical stabilizer bar by the pilots Predicted high reliability was supported by a 60-hour, trouble-free fluidic controller operation Author

N72-11938# Computing Devices of Canada, Ltd, Ottawa (Ontario)
PROJECTED MAP NAVIGATION IN MILITARY HELICOPTERS: APPLICATIONS AND OPERATIONAL EXPERIENCE
R I MacNab and J C Alexander *In* AGARD Helicopter Guidance and Control Systems Sep 1971 10 p refs (See N72-11915 03-02)
Avail NTIS

Extensive flight experience has confirmed the feasibility of the projected map navigation systems (PMS) as ideally suited for military tactical aircraft, particularly helicopters The reasons for this conclusion are explained in detail, and by documented comment from flight trial reports The basis for concluding that the PMS are fundamentally superior to present day conventional navigation systems is also explained In addition a recommendation is made for implementing a particular projected map system which has been developed to the flyable prototype stage D L G

N72-11939# Centre d Essais en Vol, Bretigny-Sur-Orge (France)
EXPERIENCE OF THE FRENCH FLIGHT TEST CENTER IN ALL-WEATHER HELICOPTER LANDING [EXPERIENCE DU CENTRE D'ESSAIS EN VOL FRANCAIS DANS LE DOMAINE DE L'ATTERRISSAGE TOUT TEMPS SUR HELICOPTERE] c21
P Bloch *In* AGARD Helicopter Guidance and Control Systems Sep 1971 6 p In FRENCH (See N72-11915 03-02)
Avail NTIS

Approach and landing under bad visibility conditions was the object of numerous tests for more than ten years The performance and safety of systems was evaluated with an eye to their certification A five-year study on the utilization of a radioelectronic rectilinear array for helicopter guidance is discussed Transl by K P D

N72-15958# Advisory Group for Aerospace Research and Development, Paris (France)
OPTIMALITY CRITERIA IN STRUCTURAL DESIGN
W Prager (Brown Univ.) Dec 1971 16 p refs
(AGARD-R-589-71) Avail NTIS

The derivation of optimality conditions from extremum principles of structural theory is reviewed, with special emphasis on conditions for global optimality. Following a brief introduction, the optimal design of sandwich structures is discussed for a single behavioral constraint and for multiple constraints Structural elements with solid sections are dealt with in a separate section In addition, a three-dimensional problem is investigated that includes many problems of optimal structural design as special cases A final section presents the previously considered optimality criteria in a unified way that frequently suggests the form of optimality conditions in new situations Author

N72-20976# Advisory Group for Aerospace Research and Development, Paris (France).
FLIGHT TEST TECHNIQUES Agard Conference Proceedings
Feb. 1971 239 p refs Papers presented at the 38th Meeting of the Flight Mechanics Panel of AGARD, Toulouse, 10-13 May 1971
(AGARD-CP-85) Avail: NTIS

The proceedings of a conference on aircraft flight test techniques are presented. Subjects discussed are: (1) stability and control tests with emphasis on supersonic and V/STOL aircraft, (2) performance measurements of extremely fast aircraft, (3) gliding reentry vehicle tests, (4) aircraft carrier operational suitability tests, and (5) evaluation of air breathing propulsion systems. Data reduction for determining the aerodynamic characteristics of aircraft and comparison with wind tunnel test results are emphasized. The views of personnel from test pilot schools regarding flight test procedures are included. For individual titles, see N72-20977 through N72-20996.

N72-20977# Boeing Co., Seattle, Wash. Flight Test Engineering - Operations.
STABILITY AND CONTROL 747 FLIGHT TESTING
D. D. Archer *In* AGARD Flight Test Tech. Feb. 1972 12 p (See N72-20976 12-02)
Avail: NTIS

The basic development and FAA certification flight test program of the 747 aircraft was conducted using five test airplanes in an intensive program involving 1443 flight hours and a total of 10-2/3 months of flight testing. Each airplane was instrumented to perform assigned tasks, and sufficient duplication in instrumentation was provided to allow flexibility in re-assigning tests for schedule changes due to development contingencies. Stability and control tests were conducted on four of the airplanes and consisted of 90 hours of development tests and 72 hours of FAA tests for a total of 162 hours. In addition, airplane handling characteristics have since been evaluated by certification authorities of Great Britain, France, and Germany. All pilots who have participated in the test programs have judged the flight handling characteristics as excellent. Author

N72-20978# Aerospatiale Usines de Toulouse (France).
METHODS OF UTILIZING THE RESULTS OF FLIGHT TESTS FOR THE STUDY OF FLIGHT PERFORMANCE OF THE CONCORDE SUPERSONIC TRANSPORT [METHODES D'UTILISATION DES RESULTATS D'ESSAIS EN VOL POUR

L'ETUDE DES QUALITES DE VOL DE L'AVION DE TRANSPORT SUPERSONIQUE CONCORDE]
R. Doque and C. Pelegatti *In* AGARD Flight Test Tech. Feb. 1972 16 p In FRENCH (See N72-20976 12-02)
Avail: NTIS

The classic parameters of flight mechanics recorded onboard the Concorde are compared to those obtained by simulation. Data cover aerodynamic limitations, stability and control systems, and instrument performance. Also given are the flight parameters used to study the flight qualities and the mathematical models used to determine them. Results show small differences in form and precision accuracy of the two methods. Transl. by E.H.W.

N72-20979# Air Force Flight Test Center, Edwards AFB, Calif.
AN APPROACH TO STALL/SPIN FLIGHT TEST OF MANEUVERING-TYPE AIRCRAFT
Collet E. McElroy *In* AGARD Flight Test Tech. Feb. 1972 6 p refs (See N72-20976 12-02)
Avail: NTIS

Procedures for modifying the conventional stall and spin type of flight tests on high performance aircraft are presented. Specific aspects of the stall and spin tests are: (1) evaluation of natural/artificial stall warning that indicates the approach of maximum usable lift, (2) determination of the angle of attack for maximum usable lift, (3) evaluation of natural/artificial loss-of-control warning and tests of departure prevention device, and (4) determination of all possible out-of-control events and effective recovery techniques. Examples of the control application and stall/departure entry conditions for four conditions are detailed. Author

N72-20980# Hawker Siddeley Aviation, Ltd., Kingston upon Thames (England).
THE HARRIER - SOME ASPECTS OF V/STOL STABILITY AND CONTROL FLIGHT TESTING
R. J. Balmer *In* AGARD Flight Test Tech. Feb. 1972 11 p refs (See N72-20976 12-02)
Avail: NTIS

The dynamic stability of V/STOL aircraft in general and a description of the aerodynamic characteristics of the P-1127 aircraft are presented. The techniques used for the initial hovering and transition flights of the P-1127 are described. The development of the Harrier aircraft from the P-1127 configuration is discussed. Examples are given of some of the special stability and control techniques used during development of the Harrier aircraft. Special cockpit instruments and onboard flight data recorders are described. Author

N72-20981# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
FLIGHT TESTS OF THE PERFORMANCE OF THE DO-31 AIRCRAFT [ESSAIS SUR LES QUALITES DE VOL DU DO 31]
C. Dragenow *In* AGARD Flight Test Tech. Feb. 1972 9 p In FRENCH (See N72-20976 12-02)
Avail: NTIS

A description is given of the program used to analyze the flight characteristics of the VOTOL aircraft DO-31. Studies were made of the principles of control and stability and the trans of large and small flying seats. Tests for a prototype DO-31E, are included. Transl. by E.H.W.

N72-20982# Aerospatiale Usines de Toulouse (France).
MEASURE OF PERFORMANCE. METHODS OF ANALYSIS AND APPLICATION TO THE CONCORDE [MESURE DES PERFORMANCES. METHODES D'ESSAIS EN VOL APPLIQUEES A CONCORDE]
J. Tourraille and R. Langlade *In* AGARD Flight Test Tech. Feb. 1972 19 p In FRENCH (See N72-20976 12-02)
Avail: NTIS

The principle test methods utilized in aerospace to measure the performance of the Concorde aircraft are presented. Data cover operational performance, takeoff and landing trajectories, and the precision of instruments necessary to calculate performance. Transl. by E.H.W.

N72-20983*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
TECHNIQUES FOR THE EVALUATION OF AIR-BREATHING PROPULSION SYSTEMS IN FULL-SCALE FLIGHT
Donald R. Bellman, Frank W. Burcham, Jr., and Norman V. Taillon *In* AGARD Flight Test Tech. Feb. 1972 15 p refs (See N72-20976 12-02)
(NASA-TM-X-68306) Avail: NTIS CSCL 21A

Techniques for evaluating air breathing propulsion systems in full scale flight are discussed. Examples of flight test techniques being used to measure the performance of turbojet propulsion systems are presented. Included are the determination of jet engine thrust, the study of inlet pressure phenomena, the measurement of exhaust nozzle characteristics, and the use of tufts at supersonic speeds. A flow diagram of a gas generator method of thrust calculation is illustrated. Author

N72-20984# Centre d'Essais en Vol, Bretigny-sur-Orge (France).
SOME ASPECTS OF FLIGHT MEASUREMENTS AND CALIBRATIONS
J. F. Renaudie *In* AGARD Flight Test Tech. Feb. 1972 12 p (See N72-20976 12-02)
Avail: NTIS

The calibration, application, and limitations of instruments used for flight tests are discussed. The various aspects of flight testing which are presented are: (1) airspeed measurement, effects of atmospheric pressure at supersonic speed, (3) errors introduced by pitot-static boom location, (4) atmospheric calibration curves for high and low altitude, and (5) correlation of flight test and wind tunnel test data. The main source of errors in various aspects of flight testing are examined and corrective actions are recommended. Author

N72-20985# Air Force Flight Test Center, Edwards AFB, Calif. Performance and Flying Qualities Branch.
CRUISE PERFORMANCE TESTING OF ADVANCED AIRCRAFT
Richard R. Hildebrand *In* AGARD Flight Test Tech. Feb. 1972 12 p ref (See N72-20976 12-02)
Avail: NTIS

The expanded performance capabilities of modern, high performance aircraft have necessitated the development of flight test techniques and methods of data analysis and presentation which differ from those traditionally employed. The variable-geometry wing of the F-111 presented the flight test engineer with the problem of defining and presenting cruise performance for a potentially infinite number of differently configured airplanes. The introduction of aircraft specifically designed to cruise at high supersonic Mach numbers presented still other problems. Some of the problems encountered and solutions developed during flight testing of such aircraft as the F-111, B-58, and SR-71 are presented. Author

N72-20986*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
LIFTING BODY FLIGHT-TEST TECHNIQUES
Garrison P. Layton, Jr. and Milton O. Thompson *In* AGARD Flight Test Tech. Feb. 1972 9 p refs (See N72-20976 12-02)
(NASA-TM-X-68308) Avail: NTIS CSCL 01B

Specific techniques and procedures for conducting flight tests of lifting body type aircraft are presented. The characteristics of the aircraft in transonic and supersonic flight regions were investigated. The data collection and analysis techniques with which the flight results were analyzed are outlined. Included are analog and digital matching techniques for

derivative extractions and a method for extracting lift and drag data. Problems encountered in the flight test program and methods for solving these problems are discussed. Author

N72-20987# Aerospace Engineering Test Establishment, Ottawa (Ontario).
ACCEPTANCE FLIGHT TESTING OF MILITARY AIRCRAFT
E. J. Sinnett and L. V. P. Galvin (USABPA, Ft. Worth, Tex.) *In* AGARD Flight Test Tech. Feb. 1972 4 p (See N72-20976 12-02)
Avail: NTIS

The acceptance flight test procedures developed and used by the Canadian Armed Forces are presented. The techniques are applied to all aircraft on initial delivery and following repair and overhaul to ensure proper operation of all aircraft systems by logical functional checks and quality control procedures. Crew requirements for performing the flight tests are outlined. Author

N72-20988# Naval Air Test Center, Patuxent River, Md. Carrier Suitability Branch.
CARRIER SUITABILITY TESTS
Roger M. Decker *In* AGARD Flight Test Tech. Feb. 1972 16 p (See N72-20976 12-02)
Avail: NTIS

A resume of tests performed to determine the suitability of an airplane for launching and recovery operations in aircraft carriers is presented. Carrier suitability testing involves for the most part the blending of the pilot/airframe combination with special equipment in this unique environment. Flight test methods utilized to define the performance and handling qualities of an airplane are not unique and are given only cursory treatment. Criteria which should be considered in the design of carrier-based aircraft so as to most advantageously match an airplane to the carrier environment are presented. Author

N72-20989# Air Force Flight Test Center, Edwards AFB, Calif.
FLIGHT TESTING FOR TURNING PERFORMANCE
Roger C. Crane *In* AGARD Flight Test Tech. Feb. 1972 10 p refs (See N72-20976 12-02)
Avail: NTIS

The types of performance test maneuvers used for evaluating the turning capability of military aircraft are presented. The application of the turning performance techniques to F-104, F-4, F-4E, and F-111D aircraft is discussed. The techniques for determining the turning limitations imposed by airframe lift and engine thrust production are described. Author

N72-20990# Royal Aircraft Establishment, Bedford (England).
STABILITY AND CONTROL TESTS ON A SLENDER WING RESEARCH AIRCRAFT
P. L. Bisgood *In* AGARD Flight Test Tech. Feb. 1972 13 p refs (See N72-20976 12-02)
Avail: NTIS

A variety of flight test techniques has been used to measure the stability and control characteristics of a slender-wing research aircraft as part of a program aimed at comparing wind tunnel and flight measurements. Derivatives obtained by alternative methods in flight usually showed satisfactory agreement. Conventional methods of derivative extraction proved adequate in areas where minor non-linearities occurred in the aerodynamic coefficients. Where more pronounced non-linearities exist, as in the longitudinal case, the results indicate that conventional techniques may not be entirely adequate. Author

N72-20991# Fiat S.p.A., Turin (Italy). Flight Mechanics Engineering.
AN INTEGRAL METHOD FOR EXTRACTION OF AERODYNAMIC COEFFICIENTS FROM FLIGHT-TEST DATA
G. P. Foroni *In* AGARD Flight Test Tech. Feb. 1972 6 p refs (See N72-20976 12-02)
Avail: NTIS

The application of the equations of motion methods, which in the praxis are the most advantageous, shows some difficulties and failures in the effectiveness and generality of employment. In order to overcome these deficiencies, after a short review of the principal methods, an integral procedure has been developed, which is a synthesis of the Fourier Transform and Shinbrot's methods; and it has also all the advantages of them. The method accuracy has then been improved by applying an optimization process of the mathematical model, based on the O.H. Gerlach correlation-coefficients. Author

N72-20992# Technische Hogeschool, Delft (Netherlands).
THE DETERMINATION OF STABILITY DERIVATIVES AND PERFORMANCE CHARACTERISTICS FROM DYNAMIC MANOEUVRES
O. H. Gerlach *In* AGARD Flight Test Tech. Feb. 1972 23 p refs (See N72-20976 12-02)
Avail: NTIS

Three frequency ranges of interest to the flight dynamicist are distinguished: (1) the low-frequency or phugoid and spiral mode frequency range, (2) the intermediate or short-period and Dutch roll frequency range, and (3) the high-frequency or elastic modes frequency range. Until today most flight tests for the determination of stability derivatives have been directed towards the intermediate frequency range. Since for various reasons the frequency ranges show an increasing trend to overlap for several classes of modern aircraft, flight test techniques suitable for more than one frequency range may well receive more attention. Flight tests to determine derivatives in the combined low and intermediate frequencies are described. The importance of accurate measurements and of an adequate frequency content of the input signal in the flight tests is stressed. The rationale behind the choice of the shape of the input signal used in the flight tests is given. The application of the derivatives, not only for stability and control purposes, but also for the determination of performance characteristics, is discussed. Author

N72-20993# Centre d'Essais en Vol, Istres (France).
SCHOOL OF NAVIGATION PERSONNEL FOR TESTS AND RECEPTION [L'ECOLE DU PERSONNEL NAVIGANT D'ESSAIS ET DE RECEPTION]
Francois Cousson *In* AGARD Flight Test Tech. Feb. 1972 11 p In FRENCH (See N72-20976 12-02)
Avail: NTIS

The formation of a French school, necessary to train navigation specialists in flying techniques, is discussed. The school is open to foreign personnel on an equal basis. The particular characteristics necessary for the administration of flying instruction on the ground and in the air are included. Transl. by E.H.W.

N72-20994# Air Force Flight Test Center, Edwards AFB, Calif.
US AIR FORCE AEROSPACE RESEARCH PILOT SCHOOL
Spence M. Armstrong *In* AGARD Flight Test Tech. Feb. 1972 8 p (See N72-20976 12-02)
Avail: NTIS

The organization and operation of the U.S. Air Force Test Pilot School at Edwards AFB, California is discussed. Subjects presented are: (1) the mission of the school, (2) the staff, (3) student qualification, (4) the curriculum, (5) the flying program, and (6) methods of instruction. Additional discussion is presented on the assignment of students after graduation and future plans for the school. Author

N72-20995# Royal Air Force, Farnborough (England).
TRAINING PILOTS TO ASSESS FLIGHT SYSTEMS AT THE EMPIRE TEST PILOTS' SCHOOL
A. A. Clark *In* AGARD Flight Test Tech. Feb. 1972 6 p (See N72-20976 12-02)
Avail: NTIS

The syllabus and training curriculum for the Empire Test Pilot School in England is presented. One aspect of the training, which is identified as assessment of flight systems, is emphasized.

Features of the system are: (1) a ground training program in systems and control engineering, (2) an autopilot investigation exercise, (3) two simulator exercises, (4) an inflight autopilot assessment, and (5) a flight path control system assessment.
Author

N72-20986# Naval Air Test Center, Patuxent River, Md.
US NAVAL TEST PILOT TRAINING
Robert V. Salleda *In* AGARD Flight Test Tech. Feb. 1972 15 p (See N72-20976 12-02)
Avail: NTIS

The philosophy of instruction, as it pertains to the education of U.S. Naval engineering test pilots and engineers is discussed. Selection processes, the composition of classes, and detailed scope of both academic and flight (fixed and rotary wing) syllabi are included. The fleet of aircraft is described, along with the use of each particular airplane-type in the curriculum. Also provided is a recent staff reorganization and major plans for the future which will substantially improve the student education and Navy test pilot utilization.
Author

N72-27016# Advisory Group for Aerospace Research and Development, Paris (France).
AIRFRAME/ENGINE INTEGRATION
A Ferri May 1972 197 p refs
(AGARD-LS-53) Avail: NTIS HC $12.00

Analytical and experimental methods for investigating interference problems in airplane design optimization are reported. Considered are inlet-airplane interference, nozzle geometry and exhaust jet-airplane interference dynamics of engine and airplane characteristics. For individual titles, see N72-27017 through N72-27023.

N72-27017 New York Univ., N.Y.
ENGINE AIRPLANE INTERFERENCE DEFINITION OF THE PROBLEM AND RELATED BASIC FLUID DYNAMIC PHENOMENA
Antonio Ferri *In* AGARD Airframe/Engine Integration May 1972 12 p refs (For availability see N72-27016 18-02)

The lack of simulation of the engine flow introduces substantial differences between the aerodynamics of the actual airplane and of the model tested. Characteristics related to the interference between an airplane and the engine, and their effects on the calculated performance of the airplane are integrated into analog and digital simulation, where the wind tunnel or test stand provides analog data, to improve the results.
G.G.

N72-27018 Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio
INLET/AIRPLANE INTERFERENCE AND INTEGRATION
Philip P. Antonatos, Lewis E. Surber, and Donald J. Stava *In* AGARD Airframe/Engine Integration May 1972 64 p refs (For availability see N72-27016 18-02)

The basic technological problems and potential solutions relating to the development of inlet and airframe design criteria are discussed. Results of analytical and experimental work emphasize details of closely coupled inlet airframe concepts. Inlet flow fields generated by basic forebody and forebody/wing combinations are reviewed together with an anlysis of the effects of variations in fuselage shape, forebody camber, wing geometry and inlet position. Problems associated with boundary layer development and vortex ingestion are discussed in terms of their effect on inlet design. Attitude effects such as angle of attack and angle of yaw are reviewed. The losses due to spillage, bleed and bypass flows are analyzed as they affect vehicle performance. Criteria are reviewed to minimize such loss for the development of optimal inlet/airframe performance. Specific problems relating to the subsonic-transonic flight regime and the supersonic regime are included.
Author

N72-27019 Aircraft Research Association, Ltd., Bedford (England)
EXPERIMENTAL DETERMINATION OF INLET CHARACTERISTICS AND INLET AND AIRFRAME INTERFERENCE
E. C. Carter *In* AGARD Airframe/Engine Integration May 1972 24 p refs (For availability see N72-27016 18-02)

The following experimental methods are considered: Measurement of the interference of the inlet on the airframe, measurement of the interference of the airframe on the inlet, and measurement of the performance of the inlet/airframe combination as a whole. The use of complete aerodynamic force models and partial models is discussed including the drag use of full and half model tunnel techniques. Particular attention is given to drag. Shortcomings of the present techniques are pointed out and alternative proposals are made where possible.
Author

N72-27020 Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
NOZZLE/AIRFRAME INTERFERENCE AND INTEGRATION
Felix Aulehla and Kurt Loter *In* AGARD Airframe/Engine Integration May 1972 25 p refs (For availability see N72-27016 18-02)

The main parameters involved in the interference between internal and external flow are discussed. Also considered is how these parameters in principle affect afterbody drag. Then the definition of rear end drag is given in the conventional way and also in a more relative manner approaching the physical optimum. For configurations with single and twin engines installed in the rear end of the fuselage wind tunnel test results for various nozzle concepts are presented and discussed. The geometric variations in these tests comprise boattail angle, size and location of the base, nozzle interfairings and engine spacing. Proper consideration of these geometric parameters in nozzle/airframe integration, reduces additional afterbody drag drastically in the transonic flight regime.
Author

N72-27021 National Aerospace Lab., Amsterdam (Netherlands)
EXPERIMENTAL DETERMINATION OF NOZZLE CHARACTERISTICS AND NOZZLE AIRFRAME INTERFERENCE
F. Jaarsma *In* AGARD Airframe/Engine Integration May 1972 45 p refs (For availability see N72-27016 18-02)

An outline is given under which circumstances certain jet flow and nozzle parameters should be simulated in the wind tunnel for both installed thrust and drag determination. The circumstances relate to the flight regimes, nozzle types and engine installation configurations. Next the technical requirements for the wind tunnel and the model are given and the difficulties in fulfilling these requirements are discussed. The techniques and schemes as used by the various groups in the AGARD countries are reviewed. Special attention is given to miniature turbo engine simulators.
Author

N72-27022 Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
DYNAMIC CHARACTERISTICS OF ENGINE INLETS
Demetrius Zonars *In* AGARD Airframe/Engine Integration May 1972 16 p refs (For availability see N72-27016 18-02)

Inlet random pressure fluctuations and their effects on reducing the stall margin of turbojet engines are discussed. A review is accomplished of the TF-30/F-111 compatibility study over the past several years. The practicality of utilizing steady state and instantaneous distortion factors to determine inlet-engine compatibility is assessed and recent advances in inlet research configurations with associated steady state and dynamic distortions are presented. Finally, a complete random data acquisition, editing, and processing method is developed for accomplishing data analysis as an inlet diagnostic tool.
Author

N72-27023 Naval Postgraduate School, Monterey, Calif.
ENGINE INTEGRATION AND THRUST/DRAG DEFINITION
Allen E. Fuhs *In* AGARD Airframe/Engine Integration May 1972 21 p refs (For availability see N72-27016 18-02)

Various definitions relating to thrust and drag are considered. Since thrust minus drag is of primary interest, the background on drag determination is discussed. This is followed by testing techniques for full scale propulsion systems. Sources of installation losses are of considerable interest. Several different methods have evolved to account for various terms in a drag/thrust determination. Bookkeeping of forces and momentum flux is described. Any aircraft development is controlled by schedules and fixed resources. Influence of these constraints on engine-airframe integration is discussed. Some special integration problems, e.g., engine bleed air, are considered. Author

N72-32017# Advisory Group for Aerospace Research and Development, Paris (France).
HANDLING QUALITIES CRITERIA
Jun. 1972 293 p refs Proc. of the AGARD Flight Mech. Panel Specialists Meeting, Ottawa, 28 Sep.-1 Oct. 1971
(AGARD-CP-106) Avail: NTIS HC $17.00

The proceedings of a conference on the handling qualities of aircraft are presented. Subjects discussed are: (1) flying qualities requirements and criteria for conventional and V/STOL aircraft (2) commercial flying quality standards and flight test validation, (3) establishment of flying qualities by analysis of current aircraft, simulation and analysis, and pilot opinion ratings, (4) special problems and interfaces in aircraft control, and (5) man machine relationships and research and development projects for improvement. For individual titles, see N72-32018 through N72-32038.

N72-32018 Service Technique Aeronautique, Paris (France).
COMPARISON OF FRENCH AND UNITED STATES FLYING QUALITIES REQUIREMENTS
Jean-Claude Wanner and John W. Carlson (ASD) *In* AGARD Handling Qualities Criteria Jun. 1972 15 p (For availability see N72-32017 23-02)

The flying qualities requirements for French and United States aircraft are compared. It was determined that the two sets of criteria are basically the same in intent and goals. The complications in applying these criteria to modern, high performance aircraft are discussed. Concepts in level of handling qualities, application of flight envelope restrictions, and effects of system failures on flying properties are examined. Author

N72-32019 Aeroplane and Armament Experimental Establishment, Boscombe Down (England).
THE NATURE AND USE OF THE RULES FOR JUDGING THE ACCEPTABILITY OF THE FLYING QUALITIES OF FIXED WING AIRCRAFT
S. J. Andrews *In* AGARD Handling Qualities Criteria Jun. 1972 10 p ref (For availability see N72-32017 23-02)

The flying qualities requirements for the United Kingdom and the United States are compared. The documents involved in establishing the criteria are examined. The general content of the documents in relation to the requirements of the flight tester in assessing the acceptability of fighter aircraft, strike aircraft, and trainer aircraft is discussed. Comment is submitted on the flying qualities requirements for V/STOL aircraft. It is suggested that the requirements documents are of limited use to the flight tester because they are either out of date or inapplicable to new aircraft with special role demands or novel design features. It is recommended that, in addition to updating existing requirements, more attention should be given to the direct and immediate application of data from known and tried service aircraft. Author

N72-32020 Federal Aviation Administration, Washington, D.C.
FAA FLYING QUALITIES REQUIREMENTS
Richard Sliff and Robert F. LeSuer *In* AGARD Handling Qualities Criteria Jun. 1972 6 p (For availability see N72-32017 23-02)

The need for flexibility and change of Federal Aviation Regulations to accommodate new designs and innovations to flying vehicles is an ever-increasing and complex situation. The current philosophies and projected difficult areas associated with airplane handling qualities are discussed. The subject is not intended to be covered as to the specific conditions or types of airplanes but, rather, to cover the qualitative evaluation needs for determining compliance with the existing airworthiness rules. Recognizing that aircraft development and capability is an ever-improving science, the relationship of Federal rulemaking procedures to the application of judgment in the requirements to produce timely and adequate determinations of compliance is discussed with consideration of complex control systems and rapidly-expanding flight envelopes. Author

N72-32021* National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.
REVISIONS TO V/STOL HANDLING QUALITIES CRITERIA OF AGARD REPORT 408
Seth B. Anderson and Laurel G. Schroers (Army Air Mobility Res. and Develop. Lab., Moffett Field, Calif.) *In* AGARD Handling Qualities Criteria Jun. 1972 8 p refs (For availability see N72-32017 23-02)

A brief review of selected handling qualities criteria for V/STOL aircraft shows that although a clearer understanding of the requirements for controversial areas such as roll control power, vertical flight path control, and transition is in hand considerably more research is needed to refine these criteria for operational IFR activity. Because many items interact to influence the pilots' overall impression of the aircraft's behaviour, additional work of a systematic nature must be done to clarify this aspect. A better definition of a gust model which includes discrete gust effects is needed to firm up criteria for both hover and STOL operation. Author

N72-32022 Cornell Aeronautical Lab., Inc., Buffalo, N.Y.
US MILITARY V/STOL HANDLING QUALITY REQUIREMENTS
Charles R. Chalk and Charles B. Westbrook (AFFDL) *In* AGARD Handling Qualities Criteria Jun. 1972 13 p refs (For availability see N72-32017 23-02)

The V/STOL aircraft handling qualities criteria specification is discussed. The evolution of the specification is traced over the five year period of its development. Problem areas requiring additional work are defined as well as research efforts to address some of the problem areas. Author

N72-32023 Canadair, Ltd., Montreal (Quebec).
APPLICATION OF V/STOL HANDLING QUALITIES CRITERIA TO THE CL-84 AIRCRAFT
O. E. Michaelsen *In* AGARD Handling Qualities Criteria Jun. 1972 26 p refs (For availability see N72-32017 23-02)

The design concepts and flight characteristics of the Canadair CL-84 tilt wing V/STOL aircraft as related to handling qualities are reviewed. The achieved characteristics are compared with the revised AGARD V/STOL Handling Qualities Criteria. It is shown that the CL-84 characteristics are in general accord with the Criteria. While a few of the Criteria values appear inappropriate for the CL-84, it is concluded that the handling qualities of the aircraft would be improved if the aircraft met most of the Criteria in the areas where it presently falls short. Author

N72-32024 Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

V/STOL HANDLING QUALITIES CRITERIA COMPARED WITH FLIGHT TEST RESULTS OF THE V/STOL SUPERSONIC FIGHTER VJ 101C AND THE V/STOL TRANSPORT AIRCRAFT DO 31E

G. K. Kissel and Horst Wuennenberg (Dornier AG, Friedrichshafen) *In* AGARD Handling Qualities Criteria Jun. 1971 16 p refs (For availability see N72-32017 23-02)

The V/STOL aircraft handling qualities criteria are compared with the flight test results for the VJ 101C V/STOL supersonic fighter aircraft and the DO 31E V/STOL transport aircraft. The main features of the takeoff and landing procedures are presented. The handling qualities of the two aircraft in hover and transition flights are compared with accepted recommendations. The influence of the stabilization system and its characteristics on the control power is examined. The effects of the jet induced downwash and of the hot gas recirculation are shown. Author

N72-32025 Air Force Flight Test Center, Edwards AFB, Calif. Performance and Flying Qualities Branch.

CRITERIA TRENDS OBTAINED FROM ANALYSIS OF CURRENT AIRCRAFT

Charles F. Adolph *In* AGARD Handling Qualities Criteria Jun. 1972 9 p refs (For availability see N72-32017 23-02)

The need for developing additional criteria specifically for evaluation purposes is discussed. Also included are discussions of several other topics in the flying qualities area which have been recurrent items of interest in evaluations of high performance aircraft. Included are comments on high angle of attack criteria, an overview of the results from evaluations of aircraft equipped with control augmentation systems, and a summary of experiences in applying flying quality criteria. Author

N72-32026 Northrop Corp., Hawthorne, Calif.

SIMULATION AND ANALYSIS IN ESTABLISHING FLYING QUALITIES CRITERIA

J. T. Gallagher *In* AGARD Handling Qualities Criteria Jun. 1972 25 p refs (For availability see N72-32017 23-02)

The application of simulation and analysis in establishing the flying qualities criteria for piloted aircraft is discussed. Two areas are identified where better criteria are needed in the specification: (1) the effects of turbulence and (2) the impact of control system dynamics on flying qualities. A discussion is presented on a program which employs ground based simulation and pilot analysis in an attempt to better define the impact of turbulence on flying qualities. Methods for overcoming existing shortcomings in the procedure are evaluated. Author

N72-32027 Boeing Co., Seattle, Wash.

HANDLING QUALITIES CRITERIA FOR SUPERSONIC TRANSPORT

W. T. Kehrer *In* AGARD Handling Qualities Criteria Jun. 1972 5 p (For availability see N72-32017 23-02)

The content and tone of a criteria specification for commercial transports are presented. A criteria must insure safe handling qualities for all regimes of flight operation. In addition to the normal flight operations, operation to the extremes of the flight envelope, and operation in severe turbulence must be specified. Also to be considered are flight operations with systems failures. A criteria specification must also consider the critical combinations of these items that have a reasonable probability of occurrence. For example, the airplane must be able to operate safely in turbulence of some specified level following flight controls systems failures. Author

N72-32028 Cornell Aeronautical Lab., Inc., Buffalo, N.Y. Flight Research Dept.

THE ROLE OF PILOT RATING IN THE DEVELOPMENT OF HANDLING CRITERIA

Robert P. Harper, Jr. *In* AGARD Handling Qualities Criteria Jun. 1972 7 p refs (For availability see N72-32017 23-02)

The application of pilot rating in determining the performance and handling criteria of aircraft is discussed. The role of pilot rating as a means of defining the quality of handling in those control situations where a direct measurement cannot be made is described. The development and application of a pilot rating scale for aircraft evaluation are examined. Author

N72-32029 London Univ. (England). Dept. of Aeronautical Engineering.

CRITERIA FOR STALL AND POST STALL GYRATIONS

G. J. Hancock *In* AGARD Handling Qualities Criteria Jun. 1972 10 p (For availability see N72-32017 23-02)

Problems associated with the handling characteristics during approaches to and excursions beyond the operational limits of commercial aircraft are discussed. The evolution of airworthiness requirements for the stall and post stall operation of aircraft is described. The effects of minimum speed in steady level flight, the specification of the factors of safety, and the demonstration of satisfactory dynamic behavior beyond the operational limits on the design of the aircraft are analyzed. Author

N72-32030 Royal Aircraft Establishment, Bedford (England).

TURBULENCE MODELS FOR THE ASSESSMENT OF HANDLING QUALITIES DURING TAKE OFF AND LANDING

J. G. Jones *In* AGARD Handling Qualities Criteria Jun. 1972 15 p refs (For availability see N72-32017 23-02)

Properties of atmospheric turbulence at low altitude are reviewed, with particular reference to those aspects relevant to an aircraft on a landing approach or during take off. Measurements of power spectra are described and related to a simplified theoretical model. Looking beyond the power spectrum, an important property of turbulence is its intermittency, related to a tendency for aircraft response to show large peaks separated by regions of relative inactivity. Pilots appear to be particularly sensitive to this intermittent structure, and their subjective comments can be related to measured turbulence characteristics. It is shown how a discrete gust model for turbulence may be employed to predict the magnitude of large response peaks. As an example, the response to gusts of an aircraft constrained to fly at constant attitude is discussed, with particular reference to the effects of aircraft speed. Author

N72-32031 North American Rockwell Corp., Los Angeles, Calif.

FLYING QUALITIES INTERACTION WITH ELASTIC AIRFRAMES

John H. Wykes *In* AGARD Handling Qualities Criteria Jun. 1972 13 p refs (For availability see N72-32017 23-02)

The trends in modern aircraft structural design and aerodynamics are such that vehicle flexibility increasingly impacts on vehicle flying (handling) qualities and the design processes necessary to provide satisfactory vehicles. In recent years, the flexibility effects on ride quality have impacted on handling qualities and, perhaps, should be added to handling qualities requirements or criteria. A presentation is given of some of the approaches currently being considered to reduce this interaction. These include such techniques as active seat isolation and active structural mode control. It is concluded that any ride quality solution method that includes inducing motion between the pilot and his controls and displays should be excluded by handling qualities criteria. The structural flexibility and flight controls interface is briefly examined, and a typical pilot-induced structural

excitation is discussed. It is suggested that a pilot prefilter, a modern stability augmentation system, and a structural mode control system designed to meet ride quality criteria can solve the problem without additional criteria. The handling qualities flexibility interaction and the vehicle design cycle are discussed.
Author

N72-32032 Societe Nationale Industrielle Aerospatiale, Toulouse (France).
INFLUENCE OF THE DESIGN AND FUNCTIONING CHARACTERISTICS OF THE FLYING CONTROL SYSTEM OF A TRANSPORT AIRCRAFT ON ITS FLIGHT QUALITIES
R. Deque *In* AGARD Handling Qualities Criteria Jun. 1972 12 p (For availability see N72-32017 23-02)
The problems encountered in the course of flying quality studies for both a supersonic and a subsonic transport aircraft are described. A study is made of the influence of the static and dynamic characteristics of controls between cockpit controls and surfaces without automatic compensators. The specific problems raised by automatic compensators are examined. A study is made of how flying qualities are affected by flying control failures and by the safety and reliability objectives which must as a consequence be achieved.
Author

N72-32033 National Aeronautical Establishment, Ottawa (Ontario).
PARAMETERS AFFECTING LATERAL DIRECTIONAL HANDLING QUALITIES AT LOW SPEEDS
K-H. Doetsch, Jr. *In* AGARD Handling Qualities Criteria Jun. 1972 13 p ref (For availability see N72-32017 23-02)
A study is undertaken of the factors affecting the lateral-directional handling qualities of aircraft in typical VMC STOL flight as certain model parameters are varied. It is found that for the low flight-speed and the low dutch roll frequencies investigated, the side force equation takes on added significance in establishing the oscillatory mode through the vector contribution of the weight component acting along the y-axis. When this contribution is large, secondary effects on handling qualities can arise if the relationship between the yaw rate and sideslip vectors in the oscillatory mode is established solely by varying the derivatives of the moment equations because, under these circumstances, unusual groups of derivatives may be necessary to satisfy the imposed constraints. Similar deviations from normal values for the moment derivatives may be required to force the zeros from the poles in the bank angle to aileron-control transfer function while simultaneously maintaining the correct vector relationships in the oscillatory mode.
Author

N72-32034 Technische Hogeschool, Delft (Netherlands).
PILOT VEHICLE ANALYSIS
R. J. A. W. Hosman *In* AGARD Handling Qualities Criteria Jun. 1972 25 p refs (For availability see N72-32017 23-02)
An experiment is described in which measurements were performed on human operators in single axis tracking tasks. The controlled element used was a simulated transport aircraft, the angle of pitch was controlled by the human operator. The forcing function was a gust signal acting on the simulated aircraft. The aircraft was simulated at three centre of gravity positions at which it was stable, neutral and unstable respectively. During the test runs the human operators had to perform simultaneously an auditory additional task. On the basis of the results obtained from the experiment a new sampled data pilot model is discussed
Author

N72-32035 Forschungsinstitut fuer Anthropotechnik, Meckenheim (West Germany).
PILOT WORKLOAD
R. K. Bernotat and Jean-Claude Wanner (Service Tech. Aeronautique, Paris) *In* AGARD Handling Qualities Criteria Jun. 1972 9 p refs (For availability see N72-32017 23-02)
Schematic diagrams and analyses of the functions of the human operator in the guidance and control loops are presented. Three hierarchical control loops are considered. Flow charts are established to define the stimuli received by the pilot, the data treatment by the brain, and the subsequent physical actions. The application of the analyses to establishing the pilot workload encountered for various portions of the flight is described.
Author

N72-32036 Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
THEORETICAL PILOT RATING PREDICTIONS
Ronald O. Anderson *In* AGARD Handling Qualities Criteria Jun. 1972 14 p refs (For availability see N72-32017 23-02)
Methods for specifying flying qualities of aircraft are discussed. Methods for correcting deficiencies in the present system are recommended. The recommendations range from the expansion of the classical approach to new dimensions to approaches that rely on theoretical predictions of pilot ratings. It is shown that the prediction of pilot ratings is a valid approach which is accurate within the range of pilot variability.
Author

N72-32037 Naval Air Systems Command, Washington, D.C.
RECENT US NAVY FLYING QUALITIES RESEARCH
Raymond F. Siewert *In* AGARD Handling Qualities Criteria Jun. 1972 12 p refs (For availability see N72-32017 23-02)
The results of U.S. Navy sponsored flying qualities research conducted over the past five years are presented. Inflight variable stability airplane investigations were conducted in simulated carrier approaches to determine the effect of the principle flying qualities parameters on approach performance. Limits have been established on the values of the major longitudinal and lateral-directional parameters, to insure good carrier approach characteristics. In addition to the carrier approach studies, moving base simulator investigations were conducted to further develop criteria, and extend the aircraft maneuvering potential at high angles-of-attack. The inclusion of maneuvering force gradient and/or stick sensitivity has been determined as a requirement for a meaningful criterion.
Author

N72-32038* National Aeronautics and Space Administration, Washington, D.C.
RECENT NASA HANDLING QUALITIES RESEARCH
Richard J. Wasicko *In* AGARD Handling Qualities Criteria Jun. 1972 25 p refs (For availability see N72-32017 23-02)
A comprehensive review of NASA research results documented since the mid-1960's and some recently completed programs on aircraft handling qualities are presented. In addition to handling qualities research pertaining to vehicle stability and control characteristics, investigations related to specialized piloting tasks, cockpit displays, and environmental factors are summarized. The background leading to NASA's handling qualities research activities is discussed, and programs that have received major emphasis are indicated. For general aviation aircraft, the survey includes investigations aimed at improving handling qualities by incorporating increasingly sophisticated stability augmentation and display systems, simplifying the approach and landing task for relatively inexperienced pilots, and establishing the basic effects of turbulence. Research on the specialized piloting problem of steeper instrument approaches for noise abatement and investigations with a representative first generation aircraft are reviewed in the section on subsonic jet transports. Supersonic cruise aircraft programs include a variety of simulation studies related to supersonic transport designs and flight tests with the XB-70 aircraft. Investigations of high angle of attack loss of control problems and a flight study of direct lift control utilization for formation flying and aerial refueling are discussed in the review of tactical military aircraft research.
Author

N73-11020# Advisory Group for Aerospace Research and Development, Paris (France)
INTERACTION OF HANDLING QUALITIES, STABILITY, CONTROL AND LOAD ALLEVIATION DEVICES ON STRUCTURAL LOADS Summary Report
Clifford F. Newberry (Boeing Co., Wichita, Kan.) Jul. 1972 17 p refs

(AGARD-R-593) Avail NTIS HC $3 00

A questionnaire was forwarded to working group members, soliciting answers from their respective countries on techniques used in considering the various interactions The questionnaire discusses possible effects of load alleviation devices from both static and fatigue loads. Interactions between stability, control, and structural loads when structural modes coalesce with rigid body short period modes are also addressed The replies received are summarized The replies generally agree, although differences between manufacturers of fighter and transport aircraft are evident. Author

N73-13018# Advisory Group for Aerospace Research and Development, Paris (France)

AGARD FLIGHT MECHANICS PANEL SYMPOSIUM ON STABILITY AND CONTROL Technical Evaluation Report

William T Hamilton (Boeing Co., Seattle) Oct. 1972 10 p refs Conf held at Brunswick, 10-13 Apr. 1972

(AGARD-AR-48) Avail NTIS HC $3 00

With the passing of time and better understanding of the aerodynamic and structural characteristics of aircraft configurations the opportunities to improve aircraft performance, reliability, or cost through the use of more sophisticated control systems was recognized These advanced control systems involved additional disciplines such as complicated mechanisms, hydraulics, electronics, and new visual systems Author

N73-13019# Advisory Group for Aerospace Research and Development, Paris (France)

A RELATION BETWEEN MEASURED CENTER OF GRAVITY VERTICAL ACCELERATIONS AND THE LOADS AT THE T-TAIL OF A MILITARY AIRPLANE

O. Buxbaum (Lab fuer Betriebsfestigkeit, Darmstadt-Eberstadt West Germany) Sep 1972 20 p refs

(AGARD-597) Avail NTIS HC $3 00

A method for the establishment of a statistical basis for the relations between center of gravity vertical accelerations and structural loads on a tailplane is described The development and application of a fatigue meter for this purpose are discussed Bending moments and load factors are plotted as graphs to show reliability of test procedures Author

N73-14998# Advisory Group for Aerospace Research and Development, Paris (France)

FLUID DYNAMICS OF AIRCRAFT STALLING

Nov 1972 342 p refs Partly in ENGLISH and partly in FRENCH Presented at Fluid Dyn. Panel Specialists Meeting, Lisbon, 25-28 Apr 1972

(AGARD-CP-102) Avail NTIS HC $19 25

The proceedings of a conference on the fluid dynamics of aircraft stalling are presented The subjects discussed are (1) two dimensional laminar separation bubbles, (2) turbulent boundary layers flows, (3) aerodynamics of high lift airfoil systems, (4) low speed stalling of wings with high lift devices, (5) stall characteristics of various military aircraft, and (6) airflow separation and buffet onset during fighter aircraft maneuvers. For individual titles, see N73-14999 through N73-15020

N73-14999 Queen Mary Coll., London (England) Dept of Aeronautical Engineering

ROLE OF FLUID DYNAMICS IN AIRCRAFT STALL AND POSTSTALL GYRATIONS

G J Hancock *In* AGARD Fluid Dyn of Aircraft Stalling Nov 1972 16 p refs (For availability see N73-14998 06-02)

The airworthiness requirements for stall and post stall behavior of an aircraft are reviewed. The definition of stall as the limiting condition for normal flight operations is established The distinct dynamic and aerodynamic contributions to a stall maneuver and post stall gyration are described The pilot's influence is assessed and some implications on airframe design are outlined The effects of flow separation on wings, the control of flow separation, and the role of model experiments are reported Author

N73-15000 Technische Hogeschool, Delft (Netherlands). Dept. of Aeronautical Engineering

SOME RESEARCH ON TWO DIMENSIONAL LAMINAR SEPARATION BUBBLES

E. Dobbinga, J. L. Vaningen, and J. W. Kooi *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 8 p refs (For availability see N73-14998 06-02)

Empirical information on the angle at which the separation streamline leaves the wall, in wall flow, was obtained. The laminar part of separation bubbles in two dimensional incompressible flow was calculated for the following conditions (1) plane stagnation point boundary layer flow, (2) flow around a cylinder 70 millimeters in diameter, (3) flow around a cylinder 400 milimeters in diameter, (4) a long cylinder, axially aligned with the wind, separation induced by a forward facing step, (5) a short flat plate with separation induced by auxiliary airfoils, (6) a short flat plate with separation induced by a forward facing step, and (7) a long flat plate with separation induced by a forward firing step. The measured angles are plotted as a function of the Reynolds number at separation Author

N73-15001 Centre National de la Recherche Scientifique, Meudon (France)

THEORETICAL AND EXPERIMENTAL RESEARCH OF TAKE OFF DRAG DEFORMATION OF LOCAL SURFACE [RECHERCHES THEORIQUES ET EXPERIMENTALES SUR LES DECOLLEMENTS LIES A UNE DEFORMATION LOCALE DE SURFACE]

S. Burnel, G. B Diep, P. Gougat, and B. Prunet-Foch *In* AGARD Fluid Dyn of Aircraft Stalling Nov 1972 11 p refs In FRENCH (For availability see N73-14998 06-02)

A theoretical and experimental study was made of incompressible flow during takeoff Velocity profiles were measured in the boundary layer by hot wire anemometers, and the signals obtained used to determine frequency distribution Static pressure distribution on the inner surface was also determined A plate containing a cavity was used to measure deformation on the hollow ledge. Spectral density fluctuations in velocity permits the measurement of natural instabilities in the boundary layer The instabilities are correlated with exterior speed Author

N73-15002 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

AIRFOIL STALL PREDICTION IN INCOMPRESSIBLE FLOW

Michel Vincent DePaul *In* AGARD Fluid Dyn of Aircraft Stalling Nov 1972 15 p refs In FRENCH; ENGLISH summary (For availability see N73-14998 06-02)

A calculation method is proposed to calculate the small separation zones which are initiated near the leading edge of an airfoil at incidence This calculation provides the details of the separation process and the maximum lift that may be obtained with a certain Reynolds number range Author

N73-15003 Northrop Corp., Hawthorne, Calif Aircraft Div

PARAMETRIC STUDIES OF SEPARATING TURBULENT BOUNDARY LAYER FLOWS

Andrzej Wortman and W J Franks *In* AGARD Fluid Dyn of Aircraft Stalling Nov 1972 9 p refs (For availability see N73-14998 06-02)

A new technique for the exact solutions of laminar or turbulent two- or three-dimensional boundary layer flows has been developed The technique differs from previous approaches in the use of functional analysis to obtain exact semianalytical solutions in a small fraction of the computer time normally required for such computations The main advantage of the semianalytical aspect of the technique is that the functional forms of the relations in the governing differential equations are retained and the use of the computer is relegated to the performance of simple quadratures and fluid properties calculations Thus, the study of the various turbulent viscosity models is a matter of programming the model into the subroutine where such calculations are performed A wide range of eddy viscosity relations can therefore be studied in a few parametric runs A typical three-dimensional calculation at a point on a body requires 3 seconds of IBM 360/65 computer time, so that extensive parametric studies can be performed quickly and economically Author

N73-15004 Technische Hochschule, Stuttgart (West Germany) Inst. fuer Aerodynamik und Gasdynamik.
DESIGN OF AIRFOILS WITH HIGH LIFT AT LOW AND MEDIUM SUBSONIC MACH NUMBERS
F. X. Wortmann *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 9 p refs (For availability see N73-14998 06-02)
The design of airfoils with high lift at low and medium subsonic speeds is discussed. It is stated that the maximum lift of a symmetrical airfoil at low Mach numbers can be increased from 15 to 20 percent if the airfoil nose is modified and designed to yield lower velocity peaks and less pronounced laminar separation bubbles. The performance of the airfoil at various subsonic speeds and angles of attack is described. Author

N73-15005 National Aerospace Lab., Amsterdam (Netherlands).
COMMENTS ON THE METHODS DEVELOPED AT NLR FOR CONDUCTING TWO DIMENSIONAL RESEARCH ON HIGH LIFT DEVICES
O. DeVries *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 7 p refs (For availability see N73-14998 06-02)
Avail: NTIS
Two experimental approaches for analyzing two dimensional flow on high lift devices are described. The first method consists of pressure measurements at the mid-span section of a two dimensional wing with boundary layer control at the tunnel wall-wing junctions by blowing slots. The second approach consists of potential flow calculations by means of a singularity method with a source distribution on the contour of the airfoil. This is applied with a limited number of contour points on the airfoils. The calculations are compared with the experimental results. Author

N73-15006 Avions Marcel Dassault, Saint-Cloud (France).
BLOCKAGE CORRECTIONS IN BLOWING TESTS OF EFFECTS OF TAKE-OFF [CORRECTION DE BLOCAGE DANS LES ESSAIS EN SOUFFLERIE EFFETS DES DECOLLEMENTS]
Jean-Ch. Vayssaire *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 22 p refs In FRENCH, ENGLISH summary (For availability see N73-14998 06-02)
The application of blockage corrections to wind tunnel test measurements made on aircraft models is discussed. The procedure corrects the velocity to infinity upstream and restores to the wall-affected aerodynamic coefficients the values which are fairly equivalent to those obtained on a model placed in an unlimited fluid stream. The corrective blockage terms which modify the reference kinetic pressure are analyzed. The terms are affected by volume, wake, and separations. Each of them is usable in incompressible, compressible, two dimensional, and three dimensional flows on whole or half models. Author

N73-15007 Douglas Aircraft Co., Inc., Santa Monica, Calif.
AERODYNAMICS IN HIGH LIFT AIRFOIL SYSTEMS
A. M. O. Smith *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 27 p refs (For availability see N73-14998 06-02)
The aerodynamic processes that occur in flow past unpowered multi-element airfoils in the high lift attitude are discussed. Charts showing permissible pressure recovery for retarded flows are presented. The best possible load carrying pressure distributions are described, as well as airfoils that develop the maximum possible lift in fully attached flow. It is shown that for a given optimum type of pressure distribution a two-element airfoil can develop more lift than a single element airfoil shaped to develop the same pressure distribution. Author

N73-15008 Royal Aircraft Establishment, Farnborough (England).
THE LOW SPEED STALLING OF WINGS WITH HIGH LIFT DEVICES
D. N. Foster *In* AGARD Fluid Dyn. of Aircraft Stalling Nov 1972 12 p refs (For availability see N73-14998 06-02)
The mechanism of the stall of wing sections with high-lift devices in two dimensional flow is discussed. The similarities to the stalling mechanism for single airfoils, and the differences which arise as a result of the close proximity of the multiple lifting elements of the wing section to each other are described. The effect of sweepback is discussed for an infinite sheared wing and for a finite aspect ratio wing with high lift devices. The effects of practical features such as part-span flaps, and flap and slat support brackets, are illustrated by reference to flow patterns measured on a swept back wing. Author

N73-15009 General Dynamics/Fort Worth, Tex.
A SIMPLIFIED MATHEMATICAL MODEL FOR THE ANALYSIS OF MULTIELEMENT AIRFOILS NEAR STALL
I. C. Bhateley and R. G. Bradley *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 12 p refs (For availability see N73-14998 06-02)
Potential-flow analysis methods, based on distributed-singularity models, are adequate for the prediction of aerodynamic characteristics for 2-D multiple-airfoil systems where viscous effects are negligible. However, for analysis and design of high-lift systems where viscous effects dominate, potential-flow methods are not adequate. In order that these viscous effects may be accounted for, a method has been formulated by which a solution is obtained through analysis of an equivalent airfoil system in potential flow. The mathematical model for the equivalent system consists of a linearly varying vorticity distribution over the surface of each airfoil element and a source distribution embedded inside each airfoil element to simulate the separated wake. The boundary-layer displacement thickness is superimposed on the airfoil contour to form an equivalent airfoil surface for each element. The flow downstream of a separation point is allowed to develop as a free streamline flow with no surface boundary conditions. The mathematical model is evaluated for cases where the location of the separation point is specified from experimental data. The predicted chordwise pressure distributions are shown to correlate well with experimental data for several multiple airfoils (including leading edge slats and trailing-edge slotted flaps) for angles of attack near stall. Author

N73-15010 Royal Aircraft Establishment, Farnborough (England).
THE EFFECT OF LEADING EDGE GEOMETRY ON HIGH SPEED STALLING
G. F. Moss, A. B. Haines (Aircraft Res. Assoc.), and R. Jordon (Aircraft Res. Assoc.) *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 16 p refs (For availability see N73-14998 06-02)
It is shown by means of an example how small modifications to the leading-edge profile of a sweptwing can result in large effects on lift performance at the stall in the higher range of subsonic speeds. The basic types of leading-edge pressure distribution for any one fixed geometry over the whole range of subsonic speed are discussed and the difficulties in designing a profile shape which gives a satisfactory compromise in wing performance across this range is emphasized. Two types of variable-geometry device at the leading edge are discussed, each of which allows some degree of optimization in the shape required for good aerodynamic performance across the range of Mach numbers. Author

N73-15011 Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Control Criteria Branch.
A PRACTICAL LOOK AT THE STALL AND HIGH LIFT OPERATION OF EXTERNALLY BLOWN FLAP STOL TRANSPORT CONFIGURATIONS
David J. Moorehouse *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 13 p refs (For availability see N73-14998 06-02)
Some practical design aspects of the stall of powered-lift aircraft having externally blown flaps are considered. Techniques are examined for predicting the increment in maximum lift coefficient due to power. Numerical results are presented for an existing theory based on the assumption of a leading-edge stall and the use of basic jet-flap theory. The accuracy of the theory is better than might be expected, and an empirical factor is added to produce good correlation with measured values. A completely empirical approach is shown to be effective as a simple technique to provide quick approximations to the increment in maximum lift coefficients. Author

N73-15012 British Aircraft Corp., Warton (England). Aerodynamics Dept.
FLIGHT DEVELOPMENT OF THE STALLING CHARACTERISTICS OF A MILITARY TRAINER AIRCRAFT

W. D. Horsfield and G. P. Wilson *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 9 p (For availability see N73-14998 06-02)

The modifications to the Jet Provost Mk. 5 and the Strikemaster 167 aircraft to improve the stall warning characteristics are reported. The procedures for obtaining the desired characteristics of a clearly marked stall with adequate warning of the approach without penalty on maximum lift and without involving large aircraft modifications are described. Diagrams and illustrations of the final configurations are included. Author

N73-15013 General Dynamics/Fort Worth, Tex.
STALL/POST-STALL CHARACTERISTICS OF THE F-111 AIRCRAFT
Charles A. Anderson *In* AGARD Fluid Dyn of Aircraft Stalling Nov 1972 9 p (For availability see N73-14998 06-02)

The stall/post-stall characteristics of the F-111 aircraft are described. The characteristics have been defined on the basis of wind tunnel tests, free-flight model tests, radio controlled drop model tests, analytical analysis, and flight tests. The extent of each type of testing is discussed and a summary of the results is presented. A discussion of the regression techniques used to obtain aerodynamic derivatives in the high angle of attack simulator is included. Author

N73-15014 Hawker Siddeley Aviation, Ltd., Kingston upon Thames (England)
POST-STALL AERODYNAMICS OF THE HARRIER GR1
Cliff L. Bore *In* AGARD Fluid Dyn of Aircraft Stalling Nov 1972 7 p refs (For availability see N73-14998 06-02)

The post-stall aerodynamics of the Harrier GR1 aircraft are discussed. The requirement to achieve high usable lift coefficients during maneuvering at subsonic speeds, without incurring a weight penalty for leading edge devices is described. The resulting characteristics of boundary layer separation after buffet onset are analyzed. The effects of arrays of fences and vortex generators are examined. Author

N73-15015 Royal Netherlands Aircraft Factories Fokker, Amsterdam
AERODYNAMICS OF WING STALL OF THE FOKKER F28
Tj. Schuringa *In* AGARD Fluid Dyn. of Aircraft Stalling Nov 1972 5 p (For availability see N73-14998 06-02)

The aerodynamic development of the F28 wing with regard to the stall are described. First, the investigation in the wind tunnel is reported, dealing with the influence of boundary layer fences, secondly the correlation with flight tests is presented. It may be concluded that, apart from minor modifications, satisfactory agreement was found between wind tunnel and flight test results. Author

N73-15016 Boeing Co., Seattle, Wash.
PREDICTING THE LOW SPEED STALL CHARACTERISTIC OF THE BOEING 747
John K. Wimpress *In* AGARD Fluid Dyn of Aircraft Stalling Nov. 1972 9 p (For availability see N73-14998 06-02)

The pre-flight estimates for the Boeing 747, based on wind tunnel data obtained at a Reynolds Number of approximately 1 million, are presented. These test results were adjusted to full scale flight values using correlation factors developed from other Boeing transport airplanes. As an independent check, high lift data were obtained in a pressurized wind tunnel up to a Reynolds Number of 7.5 million and extrapolated to the full scale value of 40 million. Flight results show that the correlation factors were moderately successful in predicting stall speeds. Also, extrapolating the pressure tunnel data to full scale Reynolds Numbers predicted the flight value of maximum lift coefficient with reasonable accuracy. The wind tunnel data at all Reynolds Numbers predicted satisfactory handling characteristics throughout the stall that were confirmed during flight testing. Author

N73-15017 Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Aeromechanics Branch
ON AIRFLOW SEPARATION AND BUFFET ONSET DURING FIGHTER AIRCRAFT MANEUVERING
Peter J. Butkewicz *In* AGARD Fluid Dyn of Aircraft Stalling Nov 1972 10 p refs (For availability see N73-14998 06-02)

An experimental flight test program was sponsored to determine the buffet characteristics of four high performance aircraft. The aircraft were flown in transonic maneuvers encountering conditions of buffeting onset through heavy buffeting. The aircraft were instrumented with accelerometers, wing root strain gages, wing static pressure taps, and one wing was tufted for flow visualization photographs. The aircraft were flown in the baseline configuration as well as with various deflections of leading and trailing edge flaps. The results of the flight test program, the effects of mechanical high lift devices on buffet, and some wind tunnel/flight test correlations are presented. Author

N73-15018 Royal Aircraft Establishment, Bedford (England)
THE DYNAMIC ANALYSIS OF BUFFETING AND RELATED PHENOMENA
J. G. Jones *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 10 p refs (For availability see N73-14998 06-02)

A dynamic analysis of buffeting and related aerodynamic phenomena is presented. The closed-loop interaction between the fluid motion, involving separated flow, and the motion of the wing surface is analyzed. The problem of formulating an appropriate theoretical model for buffeting is discussed. An analogous problem concerning the choice of appropriate analytical models for oscillatory rigid-body motion, known as wing rocking, is examined. Buffeting measurements obtained from flight tests of small combat trainer aircraft are included. Author

N73-15019* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
MANEUVER AND BUFFET CHARACTERISTICS OF FIGHTER AIRCRAFT
Edward J. Ray (McDonnell Aircraft Co., St. Louis), Linwood W. McKinney, and Julian C. Carmichael *In* AGARD Fluid Dyn. of Aircraft Stalling Nov. 1972 11 p refs (For availability see N73-14998 06-02)

The high subsonic and transonic characteristics of fighter aircraft and the factors affecting aerodynamic boundaries, such as maximum obtainable lift, buffet onset, pitchup, wing rock, and nose slice are discussed. Investigations were made using a general research configuration which encompassed a systematic matrix of wing design parameters. These results emphasized the sensitivity to section and planform geometry at the selected design point. The incorporation of variable-wing-geometry devices in the form of leading-edge slats or flaps was shown in a number of flight and wind-tunnel studies to provide controlled flow over a wide range of flight conditions and substantial improvements in maneuver capabilities. Additional studies indicated that the blending of a highly swept maneuver strake with an efficient moderately swept wing offers a promising approach for improving maneuver characteristics at high angles of attack without excessive penalties in structural weight. Author

N73-15020 Naval Air Systems Command, Washington, D.C.
AERODYNAMIC DESIGN AND FLIGHT TEST OF US NAVY AIRCRAFT AT HIGH ANGLES OF ATTACK
W. R. Burris and J. T. Lawrence *In* AGARD Fluid Dyn of Aircraft Stalling Nov 1972 10 p refs (For availability see N73-14998 06-02)

The aerodynamic design, engineering development, and flight testing of naval aircraft at high angles of attack are discussed. The flight regime beginning with buffet onset and proceeding up through departure from controlled flight is investigated. Post-stall gyrations and spin recovery are analyzed. The importance of the design process for low speed flight stability is emphasized. Author

N73-16989# Advisory Group for Aerospace Research and Development, Paris (France)
STABILITY AND CONTROL
Nov 1972 305 p refs Proceedings of the 40th Meeting of the Flight Mech. Panel of AGARD, Braunschweig West Germany, 10-13 Apr 1972
(AGARD-CP-119) Avail NTIS HC $17.25

Summaries of papers presented at conferences concerning aircraft stability, control, maneuverability and design are reported. For individual titles, see N73-16990 through N73-17013.
Author

N73-16990 National Aerospace Lab., Amsterdam (Netherlands).
SUMMARY OF AGARD MEETING ON PROBLEMS OF THE COCKPIT ENVIRONMENT, NOVEMBER 1968 IN AMSTERDAM, NETHERLANDS
J. J. P. Moelker *In* AGARD Stability and Control Nov. 1972 9 p refs (For availability see N73-16989 08-02)
Problems related to the process of man-machine communication are discussed with emphasis on cockpit information-generation, display, and transfer. Techniques for the evaluation of cockpit geometry, display systems and cockpit workload are summarized together with the associated anthropometrical data and types of display systems.
Author

N73-16991 Centre d'Essais en Vol, Bretigny-sur-Orge (France).
AEROELASTIC EFFECTS FROM A FLIGHT MECHANICS STAND POINT
J. F. Renaudie *In* AGARD Stability and Control Nov. 1972 17 p In FRENCH (For availability see N73-16989 08-02)
Methods for calculating the effects of aeroelasticity on aircraft flight are discussed. Data cover aerodynamics of flexible rotors, flight dynamics of flexible aircraft, experimental determination of flexibility for flexible aircraft, stability augmentation systems, and problems of determining influence of aerodynamic forces on flexible aircraft.
Transl. by E.H.W.

N73-16992 British Aircraft Corp., Preston (England). Military Aircraft Div.
SUMMARY PAPER ON SIMULATION MEETING, SPRING 1970 AT NASA RESEARCH CENTER
A. G. Barnes *In* AGARD Stability and Control Nov. 1972 5 p ref (For availability see N73-16989 08-02)
The conference on flight simulation is summarized. Topics discussed include: simulation objectives, simulator characteristics, design of experiments, simulation results, and analysis.
F.O.S.

N73-16993 Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
HANDLING QUALITIES CRITERIA AND REQUIREMENTS
William E. Lamar and Terry L. Neighbor *In* AGARD Stability and Control Nov. 1972 19 p refs (For availability see N73-16989 08-02)
Summaries of papers presented at the conference on flight qualities are presented. Topics discussed include: flying qualities for conventional and V/STOL aircraft, man-machine research, and the establishment of criteria.
F.O.S.

N73-16994* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CONSIDERATIONS FOR STABILITY AND CONTROL OF V/STOL AIRCRAFT: A REVIEW OF AGARD REPORT 577
Seth B. Anderson and Laurel G. Schroers (Army Mobility R and D Lab.) *In* AGARD Stability and Control Nov. 1972 10 p refs (For availability see N73-16989 08-02)
CSCL 01B
Revisions which have been made to previous V/STOL handling qualities requirements based on criteria are discussed. A discussion of the pilot's desire for a particular characteristic is given. In addition, data and reference material are provided to back up the proposed criteria to permit the user to understand the limitations of the data on which the criteria are based. A review is included of several controversial areas including pitch control sensitivity, static longitudinal stability, roll control power, roll-yaw cross coupling, and vertical flight path control.
Author

N73-16995 Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
MISSION EFFECTS ON STABILITY AND MANEUVERABILITY
Charles B. Westbrook *In* AGARD Stability and Control Nov. 1972 13 p refs (For availability see N73-16989 08-02)
The relationship between the mission requirements of a piloted aircraft and its stability and maneuverability are defined. The framework utilized in current U.S. Air Force handling qualities requirements, i.e., classification of aircraft, flight phases, levels, states, etc., is described. Examples of various aircraft designed for one mission and then utilized for other missions are given. A discussion is presented of the problems encountered when the detailed mission requirements are not clear, such as with V/STOL aircraft, reentry vehicles, etc. Problems encountered with off-design conditions and operation at the limits of the flight envelope are discussed with examples. The various methods open to the designer for achieving the proper compromises in design of an aircraft are outlined.
Author

N73-16996 British Aircraft Corp., Preston (England). Military Aircraft Div.
DESIGN CONSIDERATIONS FOR THE SATISFACTORY STABILITY AND CONTROL OF MILITARY COMBAT AEROPLANES
B. R. A. Burns *In* AGARD Stability and Control Nov. 1972 28 p refs (For availability see N73-16989 08-02)
Design criteria for achieving satisfactory stability and control for military aircraft are reviewed along with official requirements. Some of the difficulties of designing to meet the standards of these criteria are considered. Topics discussed include longitudinal stability and control, and lateral stability and control.
Author

N73-16997 Technische Hochschule, Darmstadt (West Germany).
THE EFFECTS OF THRUST CHARACTERISTICS ON LONGITUDINAL STABILITY IN SUPERSONIC FLIGHT
G. Sachs *In* AGARD Stability and Control Nov. 1972 15 p refs (For availability see N73-16989 08-02)
The influence of the variation of thrust with speed and height on the dynamic stability of the longitudinal motion in supersonic flight is shown. The effects directly related to thrust changes are described along with the effects due to pitching moments which, associated with thrust characteristics, depend on speed and height. The thrust influence on two methods of artificial stabilization of long-term modes is also investigated
Author

N73-16998 Societe Nationale Industrielle Aerospatiale, Paris (France). Departement Recherche.
INFLUENCE OF THE MASS AND MASS DISTRIBUTION ON FLYING QUALITIES [INFLUENCE DE LA MASSE ET DE LA REPARTITION DE LA MASSE SUR LES QUALITES DE VOL]
Marc Mesniere *In* AGARD Stability and Control Nov. 1972 9 p refs In FRENCH (For availability see N73-16989 08-02)
Several techniques pertinent to determining the influence of mass and mass distribution on the handling qualities of aircraft are presented. Particular attention was given to lateral and longitudinal maneuverability and the influence of inertia on the principle axis tilt angle. Several examples using a Corvett aircraft are given.
Transl. by E.H.W.

N73-16999 Royal Aircraft Establishment, Bedford (England). Aerodynamics Dept.
THE ROLE OF THEORY AND CALCULATIONS IN THE REFINEMENT OF FLYING QUALITIES
W. J. G. Pinsker *In* AGARD Stability and Control Nov. 1972 13 p refs (For availability see N73-16989 08-02)
The present state of the art in handling qualities research and design is broadly surveyed with particular emphasis on the role of theory and paper studies in this field. The significance and scope of handling criteria is critically discussed as setting targets for flying qualities design. The capabilities and limitations of theory are then considered in such areas as derivative prediction, rigid-body stability and response calculations, predictions of stability under partial constraint and under active pilot control. Finally some general consideration is given to novel flying qualities problems associated with the introduction of stability and control augmentation systems.
Author

N73-17000 Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Aerodynamics Dept.

ADJUSTMENT OF FLYING QUALITIES BY WIND TUNNEL TESTING

Tj. Schuringa *In* AGARD Stability and Control Nov. 1972 7 p (For availability see N73-16989 08-02)

Two examples of the wind tunnel approach to the flying qualities of the Fokker F28 Fellowship aircraft are described, one dealing with the development of the elevator surface, and the other with the development of stall characteristics. Author

N73-17001 Naval Air Systems Command, Washington, D.C. Advanced Technology Section.

FLIGHT SIMULATION: A SIGNIFICANT AID IN AIRCRAFT DESIGN

Ralph C. AHarrah *In* AGARD Stability and Control Nov. 1972 17 p refs (For availability see N73-16989 08-02)

The role of flight simulation in the development of the S-3 and F-14 aircraft is described along with the facilities used. An appraisal is included of simulation technology as applied to aircraft design. Author

N73-17002 Royal Aircraft Establishment, Bedford (England). Aerodynamics Dept.

THE ROLE OF FREE-FLIGHT MODELS IN AIRCRAFT RESEARCH AND DEVELOPMENT

R. Fail *In* AGARD Stability and Control Nov. 1972 14 p refs (For availability see N73-16989 08-02)

The special features of free-flight models are discussed. Two examples are given of tests in the field of flight mechanics. Preparations are described for a program of tests which is about to start at RAE to investigate the low-speed stall and post-stall dynamics of aircraft. Attention is concentrated on the planning of the tests and the instrumentation and control system in the model. Some details are given of the model handling and retrieval systems. Author

N73-17003 British Aircraft Corp., Preston (England). Commercial Aircraft Div.

THE EFFECT OF ENGINE FAILURE AT SUPERSONIC SPEEDS ON A SLENDER AIRCRAFT: PREDICTED AND ACTUAL

C. S. Leyman and R. L. Scotland *In* AGARD Stability and Control Nov. 1972 8 p (For availability see N73-16989 08-02)

The effect of engine failure on the aerodynamic characteristics of a supersonic aircraft were studied. Topics discussed include: prediction of aircraft stability derivatives, prediction of forces and moments due to engine failure, preflight simulation experience, and flight test results F.O.S.

N73-17004 Aerospatiale Usines de Toulouse (France).

CALCULATION OF INDUCED LOAD BY VARIATION IN COURSE DURING ANY MANEUVER [CALCUL DES CHARGES INDUITES PAR LA CLEXIBILITE AU COURS D'UNE MANOEUVRE QUELCONQUE]

A. Marsan *In* AGARD Stability and Control Nov. 1972 9 p In FRENCH (For availability see N73-16989 08-02)

A general formula for calculating load influence on aircraft flexibility is presented along with illustrations. A comparison was made of the load effects in rigid and transverse flexible aircraft. Three maneuvers, - lifting moments and forces, checked pitching, and checked rolling - were used for the analysis.

Transl. by E.H.W.

N73-17005* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

ACTIVE CONTROL OF AEROELASTIC RESPONSE

A. Gerald Rainey, Charles L. Ruhlin, and Maynard C. Sandford *In* AGARD Stability and Control Nov. 1972 8 p refs (For availability see N73-16989 08-02)

Conceptual and wind-tunnel programs leading to the development of technology for applying active controls to the suppression of flutter were studied to provide a powerful tool for required safety margins for flutter in future high-performance supersonic aircraft. The nature of flutter considerations in the design of the U.S. SST prototype aircraft is described as an example of the type of application where active flutter suppression shows promise. Author

N73-17006 Aeronautical Systems Div., Wright-Patterson AFB, Ohio. B-1 Airframe Div.

PREDICTION OF AEROELASTIC HINGE MOMENT EFFECTS ON STABILITY AND CONTROLLABILITY

John W. Carlson *In* AGARD Stability and Control Nov. 1972 5 p (For availability see N73-16989 08-02)

The effect of aeroelastic deflections on the stability and control characteristics are studied. Some examples of difficulties are shown that have resulted in control problems and aircraft limitations. Methods of predicting hinge moments are reviewed and some of the problems that arise by the use of these methods are discussed. A program for the analysis of structural deformations is described which may be used to analyze many aeroelastic problems. Author

N73-17007 Aeritalia, Turin (Italy).

CONSIDERATIONS ON THE MANUAL FLIGHT CONTROL DESIGN OF A MILITARY TRANSPORT AIRCRAFT

Antonio Filisetti and Giuseppe Ferretti *In* AGARD Stability and Control Nov. 1972 20 p refs (For availability see N73-16989 08-02)

Criteria for designing manual control systems for military transport aircraft are presented including a guide to the choice of the manual control parameter. Practical problems concerning the nonlinear hinge moments behavior and the control force scatter with the flight conditions are discussed. Aspects of matching manual operated ailerons with hydraulically driven spoilers are emphasized along with practical methods for designing spring-tab control surfaces. Author

N73-17008 Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).

POWERED CONTROLS, INFLUENCE ON STABILITY AND MANEUVERABILITY

Gerhard K. Kissel *In* AGARD Stability and Control Nov. 1972 13 p (For availability see N73-16989 08-02)

The influence is discussed of powered controls on the dynamic and static behavior of modern high performance aircraft. The possibilities of improving the stability and maneuverability by interconnections in the various axes are considered, and an example for a modern fighter type aircraft is demonstrated. Author

N73-17009 Boeing Co., Seattle, Wash.

FLY-BY-WIRE AND ARTIFICIAL STABILIZATION DESIGN

R. L. Schoenman *In* AGARD Stability and Control Nov. 1972 13 p (For availability see N73-16989 08-02)

The implementation of artificial stabilization to correct serious stability and control deficiencies is discussed for meeting the performance demands for aircraft which operate over a broad flight envelope such as VTOL, STOL, and SST. For this class of aircraft safety-of-flight is dependent on the integrity of these systems, and has resulted in the development of redundant system designs. The conventional SAS design approach is compared to that recommended for those vehicles which require augmentation for safety-of-flight. The impact of system redundancy on maintainability and operating costs is also discussed. A system is proposed which features integration of critical flight functions, and the use of digital computation to simplify system complexity. Author

N73-17010 Royal Aircraft Establishment, Farnborough (England). Human Engineering Div.

PILOT WORKLOAD: A CONCEPTUAL MODEL

R. G. Thorne *In* AGARD Stability and Control Nov. 1972 6 p (For availability see N73-16989 08-02)

A conceptual model is presented for the study of the situations when, some of the crew, some of the time are unable to complete satisfactorily some of their tasks. A more realistic simulation of the difficult tasks is recommended. Author

N73-17011 Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept.

THE ROLE OF THEORETICAL STUDIES OF FLIGHT DYNAMICS IN RELATION TO FLIGHT TESTING
H. H. B. M. Thomas *In* AGARD Stability and Control Nov. 1972 13 p refs (For availability see N73-16989 08-02)

It is argued that calculations have an important role to play in the planning of, the conduct of, and the analysis of flight tests. This is especially true of those areas of flight testing which involve maneuvers near limiting flight conditions in which preflight calculations are invaluable in arriving at a clearer definition of the objective of a test. Provided the aerodynamic forces acting on the aircraft can be adequately and reliably represented, there is inherent difficulty about undertaking the solution of the equations of motion in an appropriate number of degrees of freedom with the aid of available digital computers. The real problem, therefore, lies in reducing to a manageable form the output of such computer studies and thereby achieving a deeper understanding of and a more ready interpretation of the results. As an illustrative example, the longitudinal motion of an aircraft involving an extended angle-of-attack range is considered. Author

N73-17012* National Aeronautics and Space Administration. Flight Research Center, Edwards Calif
FLIGHT TEST EXPERIENCE IN AIRCRAFT PARAMETER IDENTIFICATION
Chester H. Wolowicz, Kenneth W. Iliff, and Glenn B. Gilyard *In* AGARD Stability and Control Nov. 1972 13 p refs (For availability see N73-16989 08-02)

An automatic method for determining stability and control derivatives from flight data is presented. The technique, a modification of the Newton-Raphsom method for derivative extraction, has a priori provision that makes use of initial estimates of the derivatives and provides a means of checking the validity of the results. Recommendations for applications of the method are included. Author

N73-17013 Aerospatiale Usines de Toulouse (France)
UTILIZATION OF BLACK BOXES FOR IMPROVING THE CHARACTERISTICS OF PILOTAGE DURING THE AIRCRAFT DEVELOPMENT PHASE [UTILISATION DES BOITES NOIRES POUR AMELIORER LES CARACTERISTIQUES DE PILOTAGE DURANT LA PHASE DE DEVELOPPEMENT D'UN AVION]
R. Deque *In* AGARD Stability and Control Nov 1972 12 p In FRENCH (For availability see N73-16989 08-02)

Problems encountered while trying to modify the flight control system of the Concorde aircraft during the development phase are reported. They are (1) tendency of pilot engine to pump in a lateral direction during supersonic flight, (2) consecutive skid with motor breakdown at supersonic speed, and (3) control of the aircraft after cut off of the piloting gear. The modifications made to correct these problems are given. Transl by E.H.W.

N73-18023# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT ON FLUID DYNAMICS PANEL SPECIALISTS MEETING ON FLUID DYNAMICS OF AIRCRAFT STALLING
R. C. Pankhurst (Royal Aircraft Estab., Teddington, UK) Nov. 1972 11 p refs Conf held at Lisbon, 26-28 Apr 1972
(AGARD-AR-49) Avail NTIS HC $3.00

An evaluation of the fluid dynamics of aircraft stalling is presented. The aerodynamic characteristics of the aircraft stall at both low and high speeds are discussed. Particular reference is made to the design and operation of combat and transport aircraft, including buffet penetration and post-stall behavior. Major subject areas concern flight experience, flight testing, wind tunnel measurements, and theoretical prediction methods. The effects of three dimensional flow, the influence of sweep back, and the design and performance of light lift devices are analyzed. Author

N73-18030# Advisory Group for Aerospace Research and Development, Paris (France).
RECENT DEVELOPMENTS IN FLIGHT FLUTTER TESTING IN THE UNITED STATES. SUPPLEMENT TO THE MANUAL ON AEROELASTICITY, VOLUME 4, CHAPTER 10
E. F. Baird (Grumman Aerospace Corp.) and W. B. Clark (Grumman Aerospace Corp.) Dec. 1972 27 p refs Presented at 34th AGARD Struct. and Mater. Panel Meeting, Lyngby, Denmark, 11 Apr. 1972
(AGARD-R-596) Avail: NTIS HC $3.50

Advances in the rapid and accurate determination of flutter characteristics through the use of high speed computers are discussed. Comments are presented on some flight flutter testing procedures in use and under development. A model matching technique is described. This technique reduces data analysis time and is compatible with relatively fast data acquisition. Results of model matching when applied to theoretical response data are presented and compared with actual flight flutter testing. Author

N73-20023# Advisory Group for Aerospace Research and Development, Paris (France)
A SUMMARY OF THE ANALYSIS OF GUST LOADS RECORDED BY COUNTING ACCELEROMETERS ON SEVENTEEN TYPES OF AIRCRAFT
I. W. Kaynes (RAE Farnborough) Dec 1972 713 p refs Presented at the 35th Struct. and Mater Panel Meeting, Toulouse, France, 25 Sep. 1972
(AGARD-R-605; AGARD-586-Add) Avail: NTIS HC $7.75

The collection and processing of gust load data obtained from counting accelerometers during twenty years of recording is described. Tables of the accelerations and equivalent gusts are presented, the latter having been calculated by both discrete and spectral gust models. The gust frequency distributions are discussed. Author

N73-21008# Advisory Group for Aerospace Research and Development, Paris (France)
ADVANCED ROTORCRAFT, VOLUME 1
Feb 1973 237 p refs Presented at the 39th meeting of the Flight Mech Panel of AGARD, Hampton, Va., 20-23 Sep 1971
(AGARD-CP-121) Avail NTIS HC $14.00

The proceedings of a conference on rotary wing aircraft developments are presented. The objectives of the symposium are given as (1) review of experiences gained from existing helicopter operations, (2) review of lessons obtained from flight tests of experimental helicopters, (3) discussion of the future of advanced rotorcraft, and (4) ground test facilities for research and development of new rotorcraft. For individual titles, see N73-21009 through N73-21030.

N73-21009 Service Technique Aeronautique, Paris (France)
TACTICAL FLIGHT OF HELICOPTER AND REPERCUSSIONS ON THE CONCEPTION [LE VOL TACTIQUE DE L'HELICOPTERE ET LES REPERCUSSIONS SUR SA CONCEPTION]
M. Berthoux *In* AGARD Advanced Rotorcraft, Vol 1 Feb 1973 5 p In FRENCH (For availability see N73-21008 12-02)

Certain reflections on the aspects of the problem of tactical helicopter flight are made in light of experience acquired in the domain of aeromobility. After having examined the tactical environment, research was done on the effects of such environments on helicopter performance. Transl by E.H.W.

N73-21010 Royal Aircraft Establishment, Bedford (England)
THE OPERATION OF HELICOPTERS FROM SMALL SHIPS
J. B. B. Johnston *In* AGARD Advanced Rotorcraft Vol 1 Feb 1973 15 p (For availability see N73-21008 12-02)

Procedures for operating helicopters from the decks of small ships are discussed. The subjects presented are (1) an overall view of the operation, (2) types of helicopters in use, (3) types of ships used, (4) problem of deck size and superstructure, (5) nature and effect of air flow around the ship, and (6) problem of ship motion. Preliminary flight tests to investigate the identified problems are reported. Author

N73-21011 Societe Nationale Industrielle Aerospatiale, Paris (France)
TEN YEARS EXPERIENCE WITH THE HELICOPTER FROM

OPERATION IN FRENCH ARMY [DIX ANS D'EXPERIENCE AVEC LES HELICOPTERES EN OPERATION DANS LES ARMEES FRANCAISES]
A. Renaud *In* AGARD Advanced Rotorcraft, Vol 1 Feb. 1972 3 p In FRENCH (For availability see N73-21008 12-02)
Helicopter performance as determined by a ten year study in various military environments is reported. Data cover operational systems, special equipment, and various environmental situations including tactical operations. Helicopter support activities are also discussed. Transl by E H W

N73-21012 Service Technique Aeronautique, Paris (France)
RELIABILITY AND SAFETY OF OPERATING MECHANICAL HELICOPTER PIECES [FIABILITE ET SECURITE EN OPERATION DES PIECES MECANIQUES POUR HELICOPTERES]
S Berner *In* AGARD Advanced Rotorcraft, Vol 1 Feb 1973 9 p In FRENCH (For availability see N73-21008 12-02)
After determining the service life of the mechanical parts of a helicopter, fail safe system characteristics, qualifications of transmission box mechanisms, their initial contribution and potential utilization were determined. Fabrication materials and procedures from both Britain and the U.S. are compared Transl. by E H.W.

N73-21013 Army Aviation Systems Test Activity, Edwards AFB Calif
GREATER SAFETY, MAINTAINABILITY, AND RELIABILITY THROUGH IMPROVED HELICOPTER FLIGHT TESTING
Gerald E. Swecker *In* AGARD Advanced Rotorcraft, Vol 1 Feb. 1973 15 p refs (For availability see N73-21008 12-02)
Data obtained from helicopter flight test programs are presented. Greater safety, maintainability, and reliability are being assured through constantly improved flight testing techniques and the use of state-of-the-art instrumentation, data acquisition, and data reduction equipment. More stringent helicopter performance criteria are placing greater demands on the test agencies to devise new methods and procedures for collecting and analyzing data. Included are such programs as (1) the AH-1G (Cobra) helicopter and a simplified approach to finding height loss during dive recovery from throttle chops; (2) recommendation of limiting AH-1G tail rotor control; (3) OH-6A g loads experienced at high frequencies during weapons firing; (4) recommended pilot cues to define a safe AH-1G envelope following engine failure; (5) investigation of large sideslip and pitch excursions following throttle chops in the TH-55 helicopter; (6) identification of requirements for AH-1G instrument-flight-rule (IFR) evaluation; (7) results from OH-58 and AH-1G helicopter height-velocity (H-V) (autorotational) testing with discussion of application to operational use, and (9) AH-1G maneuvering limits from return-to-target profiles. Tests conducted with the AH-1G helicopter determined return-to-target time, height lost during pullout from a dive, and other maneuvering characteristics. The concept of energy maneuverability has been established, and significant data have been added to the literature. Author

N73-21014 Naval Air Test Center, Patuxent River, Md Rotary Wing Branch
A NEW LOOK AT HELICOPTER LEVEL FLIGHT PERFORMANCE
Allen B Hill *In* AGARD Advanced Rotorcraft, Vol 1 Feb. 1973 9 p (For availability see N73-21008 12-02)
Helicopter level flight performance data are presented as power coefficient (c sub p versus tip speed or advance ratio for a range of thrust coefficients (c sub t)) This data presentation was developed from momentum and blade element theory. The power coefficient is a nondimensional expression for the main rotor shaft horsepower required. The main rotor shaft horsepower required consists of profile, parasite and induced power. The advance of tip speed ratio is a nondimensional ratio of flight and main rotor rotational speed. The thrust coefficient is a nondimensional expression for thrust required. It should probably be called the weight coefficient, since vertical drag is normally ignored, and thrust is replaced by gross weight. A representative classic helicopter level flight performance curve is presented. Author

N73-21015 Royal Aircraft Establishment, Bedford (England)
SOME FLIGHT EXPERIMENTS ON THE XH-51 N HELICOPTER
P. Brotherhood and C. A James *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 12 p refs (For availability see N73-21008 12-02)
Flight tests of the XH-51N helicopter are reported. The tests were primarily concerned with helicopter stability and control. Several combinations of gyroscopes and control springs were evaluated. The principal effects of the changes in configuration were variations in control sensitivity and rotor damping. A variation in static stability due to a differently shaped gyro arm was reported. Author

N73-21016 Messerschmitt-Boelkow-Blohm G m b H , Ottobrunn (West Germany)
INFLUENCE OF ELASTIC COUPLING EFFECTS ON THE HANDLING QUALITIES OF A HINGELESS ROTOR HELICOPTER
G Reichert and H. Huber *In* Agard Advanced Rotorcraft, Vol 1 Feb 1973 15 p refs (For availability see N73-21008 12-02)
Stability and control of a helicopter with a hingeless rotor system is mainly influenced by the elastic flapping motion of the rotor blades. On a rotor with torsionally flexible blades or elasticity in the control system there can be additional aeroelastic effects, which act as control inputs on the blades. After a short description of the rotor system and the analytical model, the reasons and the influences of elastic coupling effects on the stability and control behavior of a hingeless rotor helicopter are discussed. There are effects which result from the aerodynamic characteristics and from the chordwise mass-distribution on the blade. Additional coupling effects result from flapping and inplane deflections out of the pitching control axis similar to a pitch-flap-lag-coupling. Theoretical results are compared with flight test data. Author

N73-21017 Westland Helicopters, Ltd , Yeovil (England)
GROUND AND FLIGHT TEST EXPERIENCE WITH THE WESTLAND SCOUT HINGELESS ROTOR HELICOPTER
D. E. H Balmford *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 12 p (For availability see N73-21008 12-02)
The flight test experience gained during the basic clearance of a Westland Scout helicopter fitted with a reduced scale version of the hingeless rotor system is discussed. The basic clearance was aimed at producing an aircraft with sufficient capability to embark upon a series of research tasks and as such was devoted to investigating the airworthiness and handling of the aircraft broadly within the limit of the flight envelope of the standard production Scout fitted with an articulated rotor. Provided that these limits could be approached reasonably closely it was considered that the aircraft would be adequate for its research tasks. A statement of the present status of flight testing of the Lynx helicopter is included. Author

N73-21018 Societe Nationale Industrielle Aerospatiale, Paris (France)
SOME THOUGHTS ON THE SA 341 GAZELLE SPEED RECORD
J Soulez-Lariviere *In* AGARD Advanced Rotorcraft, Vol 1 Feb 1973 4 p (For availability see N73-21008 12-02)
The speed record establishment for helicopters by the SA 341 helicopter is discussed. The nature of the course flown and the requirements for successful completion are described. The preparation of the helicopter for the record try is reported. Lessons to be drawn from this experience for future record tries are analyzed. Author

N73-21019 Army Air Mobility Research and Development Lab , Moffett Field, Calif
PROGRESS IN ROTOR-BLADE AERODYNAMICS
P F Yaggy and I C Statler *In* AGARD Advanced Rotorcraft, Vol 1 Feb 1973 15 p refs (For availability see N73-21008 12-02)
The primary factors inhibiting the performance of rotary wing aircraft are identified. The inhibiting factors are examined and

discussed with respect to developments in the aerodynamics of the rotor, the mathematical modeling of its wake, and the prediction of dynamic airloads and their effects on flying qualities. Recent developments in rotor flow studies, rotor blade pressure distributions, rotor blade boundary layer analyses, airfoil behavior in rotors, and rotor aerodynamics are presented.
Author

N73-21020 Army Air Mobility Research and Development Lab., Fort Eustis, Va. Structures Div.
SURVEY OF ROTARY WING LOADS AND STABILITY ANALYSIS PROBLEMS
H. I. MacDonald *In* AGARD Advanced Rotorcraft, Vol 1 Feb. 1973 6 p (For availability see N73-21008 12-02)
A survey of some to the problems encountered in the prediction of structural design loads and aeroelastic stability margins during the development of rotary wing aircraft is presented. The importance of accurate prediction of structural design loads for improved reliability performance, and stability of aircraft is stressed. Variations in analysis methods employed by various manufacturers are discussed. The complexity involved in the prediction of rotary wing loads and aeroelastic stability, the effects on cost effectiveness, and areas where complex analysis is advantageous are reported.
Author

N73-21021 United Aircraft Corp., Stratford, Conn.
IMPACT OF NEW STRUCTURAL CONCEPTS ON SYSTEM CAPABILITIES
Edward S. Carter *In* AGARD Advanced Rotorcraft, Vol 1 Feb. 1973 11 p refs (For availability see N73-21008 12-02)
The impact of structural concepts on rotary wing system capabilities is examined. Current vertical takeoff aircraft system capabilities in terms of payload and gross weight ratio are reported. Examples of advances in vertical takeoff aircraft design are submitted. Specific developments in rotor blade construction, variable geometry concepts, drive systems, transmissions, and airframes are presented.
Author

N73-21022 Boeing Co., Philadelphia, Pa. Vertol Div.
EVALUATION, DEVELOPMENT, AND ADVANTAGES OF THE HELICOPTER TANDEM DUAL CARGO HOOK SYSTEM
Gregory J. Wilson and Newton N. Rothman *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 8 p refs (For availability see N73-21008 12-02)
Helicopter transport of external cargo for military applications, efficient use of available rotary-wing equipment, and enhancement of aircraft safety is examined. Improvements in this technique could provide the transport of external cargo at the maximum speed of the helicopter, routine operation under instrument flight rules (IFR), precise placement of the load, and could eliminate the problems in hover such as the dust cloud and static electricity. Feasibility studies have shown the potential of the tandem dual hook concept as a viable base on which to build an improved cargo-handling system. Production incorporation of a dual cargo hook system is planned for the heavylift helicopter (HLH). The system incorporates other features such as variable longitudinal hook positioning, differential winching, load motion feedback, and augmentation of the cargo system operator's vision under conditions of poor light and thick dust. The requirements for an improved helicopter external cargo-handling system, the programs which have established the feasibility of a tandem dual cargo hook system, and the system slated for the heavy-lift helicopter are reported.
Author

N73-21023 Westland Helicopters, Ltd., Yeovil (England)
MATERIALS FOR ADVANCED ROTORCRAFT
J. P. Jones *In* AGARD Advanced Rotorcraft, Vol 1 Feb 1973 6 p refs (For availability see N73-21008 12-02)
The development and application of composite materials for constructing airframes of vertical takeoff aircraft are discussed. The properties of carbon reinforced plastics are described and specific areas of application for airframes and rotors are identified. The design features which produce better handling qualities of rotary wing aircraft and which are possible by the use of improved composite materials are examined.
Author

N73-21024 Hawker Siddeley Aviation, Ltd., Woodford (England).
STOPPED ROTOR AIRCRAFT USING CIRCULATION CONTROLLED ROTORS
John Taylor *In* AGARD Advanced Rotorcraft, Vol. 1 Feb 1973 15 p refs (For availability see N73-21008 12-02)
The fundamental problems of the stopped rotor aircraft are examined. The aerodynamic characteristics of the circulation controlled rotor are discussed and the results of test data presented. Finally, the evolution of a typical stopped rotor aircraft design using circulation controlled rotors is illustrated.
Author

N73-21025 Giravions Dorand Co., Paris (France).
FIELDS OF APPLICATION OF JET FLAPPED ROTORS
M. Kretz *In* AGARD Advanced Rotorcraft, Vol 1 Feb 1973 12 p refs (For availability see N73-21008 12-02)
Analysis of the field of application of the jet-flap rotor shows the cost-effectiveness of this technique when applied to heavy helicopter and stoppable rotor designs. Comparison with equivalent mechanically driven heavy-lift rotorcraft shows empty-weight gains of 30 to 40 percent. Initial cost gains for these vehicles is even higher, approaching 50 percent. The feasibility of an aircraft having a 0.85 Mach number capability and possessing a stoppable and stowable nonfolding two-bladed rotor has been established. The weight analysis also demonstrates the attraction of the jet-flap concept, which combines the features of both low weight and low cost, with a long duration hovering capability. The jet-flap rotor thus makes it possible for the same aircraft to have the high airspeed characteristics of a modern airplane coupled with the lowspeed advantages of a helicopter.
Author

N73-21026 Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
RESEARCH AND DEVELOPMENT ON ROTORS WITH TIP REACTION DRIVE IN GERMANY
Christoph Fischer *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 12 p refs (For availability see N73-21008 12-02)
Activities on cold, hot and mixed cycle tip jet propulsion for rotors are reported. Research and programs on cold and large mixed cycle systems are described. For both projects some results of component testing flight tests are discussed. Aspects of the flight mechanics as decoupling of movements in hovering and advantages of wide rpm-range are shown. Concluding remarks on the operational applicability and new missions favoring torque-free rotor drive systems are added.
Author

N73-21027 Boeing Co., Philadelphia, Pa. Vertol Div.
SURVEY OF TILT ROTOR TECHNOLOGY DEVELOPMENT
K. B. Gillmore *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 11 p refs (For availability see N73-21008 12-02)
A review is made of the development of tilt rotor technology since the XV-3 program in the late 1950's. A brief comparison of the capabilities of the tilt rotor with other rotary wing configurations for a transport mission is shown. Tilt rotor performance and dynamic model tests are described. Analytical methodology development is reviewed and predictions are shown to compare well with model test data in the areas of performance, aeroelastic stability and flying qualities. It is concluded that the technology is now in hand to develop a prototype vehicle.
Author

N73-21028 Societe Nationale Industrielle Aerospatiale, Marignane (France.)
FENESTRON: NEW SOLUTION OF TAIL ROTOR [LE FENESTRON, SOLUTION NOUVELLE DE ROTOR DE QUEUE]
J. Gallot *In* AGARD Advanced Rotorcraft, Vol 1 Feb. 1973 7 p In FRENCH (For availability see N73-21008 12-02)
A method for determining flight performance and flight qualities of a Fenestron type tail rotor is presented. Data cover vulnerability, effects of vibration on stationary flight performance, flight control, and maintenance.
Transl. by E.H.W.

N73-21029 United Aircraft Corp., Stratford, Conn.
DEVELOPMENT OF THE ABC ROTOR
Robert K. Burgess *In* AGARD Advanced Rotorcraft, Vol. 1 Feb 1973 17 p refs (For availability see N73-21008 12-02)
The development of the advancing blade concept (ABC) rotor

is traced from conception through small scale model wind tunnel testing, full scale analysis, design, fabrication and ultimate wind tunnel testing of a 40 ft diameter rotor. The principal design tradeoffs resulting from the early analyses and testing are discussed along with their expected impact on the full scale rotor characteristics. Materials and manufacturing methods employed are covered including the more important difficulties that were surmounted during the nearly five years of development. Finally, the major test programs are outlined including blade balancing, turbine test bed operation and full scale wind tunnel testing facility up to speeds of 180 knots and advance ratios of .91. Significant results of these tests are presented, and applications to aircraft systems discussed. Author

N73-21030 Royal Aircraft Establishment, Bedford (England)
RAE EXPERIENCE IN THE USE OF A PILOTED GROUND-BASED SIMULATOR FOR HELICOPTER HANDLING STUDIES
T. Wilcock *In* AGARD Advanced Rotorcraft, Vol. 1 Feb. 1973 12 p refs (For availability see N73-21008 12-02)

Two studies using a ground-based piloted flight simulator for the assessment of helicopter handling qualities are described. The first simulation, of a Westland Wessex, was performed to establish the simulation techniques required for effective representation of handling behaviour. The second study was of the Westland Lynx, and was conducted prior to the first flight of that helicopter in order to provide assistance in the early development program. Results of the two simulations are discussed, and the experience gained from these tests is used to suggest some requirements for valid simulation. Author

N73-21031# Advisory Group for Aerospace Research and Development, Paris (France)
AERODYNAMICS OF ROTARY WINGS
Feb 1973 449 p refs In ENGLISH partly in FRENCH Presented at Fluid Dyn. Panel Specialists Meeting, Marseilles, 13-15 Sep 1972
(AGARD-CP-111) Avail: NTIS HC $24.50

The proceedings of a conference on the fluid dynamics of rotary wings and methods for calculation and analysis of the aerodynamics and dynamics of rotary wing systems are presented. The subjects discussed include the following: (1) calculation of rotor wake characteristics and inflow distribution, (2) factors affecting performance at hover and high advance ratio, (3) description of analytical methods for calculating rotor unsteady aerodynamics, (4) trends in rotor blade airfoil design, and (5) measurement of aerodynamic noise generated by rotary wings. For individual titles, see N73-21032 through N73-21056

N73-21032 United Aircraft Corp., East Hartford, Conn.
ROTOR WAKES: KEY TO PERFORMANCE PREDICTION
Anton J. Landgrebe and Marvin C. Cheney, Jr *In* AGARD Aerodyn. of Rotary Wings Feb. 1973 19 p refs (For availability see N73-21031 12-02)

The history of helicopter performance prediction methods and the influence of rotor wakes are traced from the simple momentum techniques used in the early years of propellers and rotors to the current state-of-the-art computer programs simulating the rotor's complex vortex structure. Analytical and experimental techniques are described which define the geometry of the vortex field of a hovering rotor and its effect on rotor performance. It was concluded that the most important factor which influences the prediction of hover performance was the interference caused by the tip vortex during its first revolution. Integrated performance in forward flight was generally not sensitive to variable inflow; however, when combined with unsteady airfoil data, variable inflow produced significant effects on blade torsional responses. Author

N73-21033 Army Air Mobility Research and Development Lab., Moffett Field, Calif.
AN ACTUATOR DISC THEORY FOR ROTOR WAKE INDUCED VELOCITIES
Robert A. Ormiston *In* AGARD Aerodyn. of Rotary Wings Feb. 1973 19 p refs (For availability see N73-21031 12-02)

A general actuator disc theory is presented for predicting the time-averaged downwash distribution and steady state force and moment response characteristics of helicopter rotors in forward flight. Particular attention is given to a proper definition of the rotor potential flow problem. The formulation of the theory is conceptually based on classical fixed wing lifting-line theory to enhance its versatility and provide insight about the complex physical features of the rotor downwash distribution. The method of solution expresses the rotor downwash in a Fourier series where the coefficients are given as a summation of influence functions. It is shown that the rotor wake vorticity can be assumed to lie in a flat planar wake for a wide range of flight conditions, thus simplifying the Biot-Savart integration for the downwash. The vorticity elements in the flat planar wake are decomposed into simple circular and linear elements to further simplify the integrations. Author

N73-21034 Westland Aircraft, Ltd., Yeovil (England).
THE STRUCTURE OF THE ROTOR BLADE TIP VORTEX
C. V. Cook *In* AGARD Aerodyn. of Rotary Wings Feb. 1973 14 p refs (For availability see N73-21031 12-02)

The results of a set of experiments to measure the velocity distribution through a helicopter rotor blade tip vortex are presented. The experiments were conducted on a single full scale rotor blade operating at a representative tip speed on a whirl tower. The rotor was mounted in the inverted position (thrusting downward) to reduce the ground effects and produce a steady flow through the rotor. The vortex velocity distributions were measured for a range of vortex ages and a number of blade loadings, the highest of which was above that normally associated with a hovering rotor. A vortex "age" range in terms of blade rotation of approximately 70 to 380 degrees of azimuth was covered. Flow visualisation using smoke was employed to determine the trajectory of the vortex and a hot wire aneomometer to measure the induced velocities associated with the tip vortex. Author

N73-21035 Georgia Inst. of Tech., Atlanta School of Aerospace Engineering
A VORTEX ANALYSIS OF A SINGLE BLADED HOVERING ROTOR AND A COMPARISON WITH EXPERIMENTAL DATA
Robin B. Gray and George W. Brown *In* AGARD Aerodyn. of Rotary Wings Feb. 1973 14 p refs (For availability see N73-21031 12-02)

A theoretical method is developed for determining the geometry and strength distribution of the vortex wake generated by a single-bladed hovering helicopter rotor. The analysis begins with a simple model of the ultimate wake geometry and then proceeds to establish the corresponding nondimensional tip-vortex strength. This simple vortex-wake model is adjusted by procedures that are based on the Biot-Savart law to obtain a first approximation for the tip-vortex geometry. Next, an estimate of the blade collective pitch angle is found from blade-element considerations. Then, a first approximation for the geometries and strengths of the vortex-sheet filaments that are shed from the blade trailing edge is determined by marching inboard from the blade tip. Thus, a simultaneous solution for the filament strengths is not required. Futher adjustments to the wake geometry, the strenghts of the inboard filaments, and the collective pitch are made until succeeding changes become acceptably small. Author

N73-21036 Societe Nationale Industrielle Aerospatiale, Marseille (France).
ROTOR STATIONARY FLIGHT AND LARGE ADVANCEMENT PARAMETERS [ROTOR EN VOL STATIONNAIRE ET A GRAND PARAMETRE D'AVANCEMENT]
J. Soulez-Lariviere *In* AGARD Aerodyn. of Rotary Wings Feb. 1973 29 p In FRENCH (For availability see N73-21031 12-02)

A technique which permits vertical flight by a helicopter rotor is disclosed. The historical development of a conduit is explored, after which the diverse shock limitations on stationary and translation flight are examined. A historical account is also given of the methods used to improve and calculate the performance of helicopter rotors. Transl. by E.H.W.

N73-21037 Societe Nationale Industrielle Aerospatiale, Marseille (France).
ROTOR REQUIREMENTS BEYOND THE USUAL FLIGHT

DOMAIN OF ONERA LARGE WIND TUNNEL AT MONDANE [COMPORTEMENT D'UN ROTOR AU-DELA DU DOMAINE DE VOL USUEL A LA GRANDE SOUFFLERIE DE MODANE]
Michel Lecarme In AGARD Aerodyn of Rotary Wings Feb 1973 14 p In FRENCH. ENGLISH summary (For availability see N73-21031 12-02)

Several series of tests have been performed on a 4.150 meter diameter experimental rotor in the large wind tunnel. The blades stiffness and available power of test equipment in the wind tunnel made a number of measurements and visualizations possible in some severe configurations and at high tip speeds. During the exploration of the test envelopes for various sets of blades, a tip speed ratio of .87 was reached. the retreating blade stall was studied at several values of pre-set parameters, such as: wind speed, rotor tip speed, rotor shaft tilt, and collective pitch. The present rotor head is not provided with cyclic pitch control. Operating limits for a conventional rotor were determined in terms of tip speed ratio. Development of retreating blade stall is affected by the reverse flow area and vortex interactions and this stall produces disturbances which increase as the tip speed ratio decreases. Author

N73-21038 United Aircraft Corp., Stratford, Conn. Sikorsky Aircraft Div.
AERODYNAMIC FACTORS INFLUENCING OVERALL HOVER PERFORMANCE
Evan A Fradenburgh In AGARD Aerodyn of Rotary Wings Feb 1973 11 p refs (For availability see N73-21031 12-02)

Improvements in basic rotor design practice are described and results of several series of model rotor tests are discussed. Moderate values of blade root cutout are shown to have an unanticipated effect on hovering efficiency. A large root cutout decreases figure of merit of the rotor, but also reduces vertical drag of a typical airframe below the rotor, cutting the aerodynamic penalty to about half of what tests of the rotor alone would indicate. Tests of a tilt-rotor model show that, unlike the conventional single rotor helicopter configuration, the rotors do not benefit from a partial ground effect caused by the airframe in the rotor downwash field. The relationship of blade twist and ground effect is discussed, and the influence of ground proximity on vertical drag is presented. It is shown that net airframe vertical drag can be zero or negative when the aircraft is close to the ground. Additional systematic experimentation is clearly needed, as is the development of theory to cover the various relationships involved in overall hover efficiency. Author

N73-21039 Dornier-Werke G.m.b.H., Friedrichshafen (West Germany)
THE ROTOR IN AXIAL FLOW
Herbert Zimmer In AGARD Aerodyn of Rotary Wings Feb 1973 16 p refs (For availability see N73-21031 12-02)

The aerodynamic characteristics of rotary wings under axial flow conditions are discussed. An outline of the calculation methods is given. A vortex method is used for one type of calculation. A momentum blade element method is applied in another case because of the widely separated flow. Emphasis is placed on quick solution of the equations because of the need for frequent use in a design cycle and during performance calculations. Author

N73-21040 Canadair, Ltd., Montreal (Quebec)
THE DEVELOPMENT OF AN EFFICIENT HOVERING PROPELLER/ROTOR PERFORMANCE PREDICTION METHOD
D. C. Gilmore and I. S. Gartshore (British Columbia Univ.) In AGARD Aerodyn of Rotary Wings Feb 1973 24 p refs (For availability see N73-21031 12-02)

The development of a method for predicting the performance of heavily loaded propellers and rotors in steady hovering flight is described. The method has two particularly useful characteristics: (1) certain simplifying assumptions which allow consistency in the analytical model to be achieved with only a few small scale iterations and (2) a need for only a part of the wake to be specified. The analytical model built up from three basic elements, includes a single vortex filament shed from the tip of each blade, a vortex sheet shed inboard of the point of maximum bound circulation on each blade, and an outboard sheet rolling up to form the tip vortex at an arbitrary angle. Roll-up angle affects the circumferential variation of induced velocity components but not their mean values. Application of the method to three propellers shows that accuracy of results is dependent upon realism of the assumed wake geometry. Author

N73-21041* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A SUMMARY OF CURRENT RESEARCH IN ROTOR UNSTEADY AERODYNAMICS WITH EMPHASIS ON WORK AT LANGLEY RESEARCH CENTER
John F. Ward and Warren H. Young, Jr. In AGARD Aerodyn. of Rotary Wings Feb 1973 20 p refs Prepared in cooperation with Army Air Mobility R and D Lab., Fort Eustis, Va. (For availability see N73-21031 12-02)

The basic unsteady aerodynamic environment of the rotary wing is summarized. Some of the observed trends in the state of the art are discussed. Some of the research needs that will require attention are reported. A review of a number of research investigations as a part of a joint NASA/Army rotorcraft project is presented. The research is directed toward achieving a better understanding of rotor unsteady airfoils. The investigations include (1) rotor maneuver loads, (2) level flight and maneuver wake prediction, (3) tip-vortex flow, (4) blade-vortex interactions, (5) dynamic stall, (6) transient Mach number air loads, and (7) development of variable geometry rotors. Author

N73-21042 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
AERODYNAMIC FORCES COMPUTATION AND MEASUREMENT ON AN OSCILLATING AEROFOIL PROFILE WITH AND WITHOUT STALL
J. J. Philippe and M. Sagner In AGARD Aerodyn of Rotary Wings Feb 1973 13 p refs In FRENCH, ENGLISH summary (For availability see N73-21031 12-02)

Research projects on computing and measuring aerodynamic forces on oscillating airfoil profiles are discussed. The problems created by unsteady aerodynamic stalling of rotary wings are emphasized. The experimental findings are analyzed as a function of mean angle of attack, oscillations amplitude, reduced frequency, and Mach number. Computed results are compared with experimental data. Author

N73-21043 Aix-Marseilles Univ. (France) Inst. de Mecanique des Fluides.
AERODYNAMIC EFFORTS ON A LARGE WING PROFILE WITH QUICK HARMONIC MOVEMENT PARALLEL TO SIEVE FLOW [EFFORTS AERODYNAMIQUES SUR UN PROFIL D'AILE ANIME D'UN MOVEMENT HARMONIQUE PARALLELE A L'ECOULEMENT MOUVEMENT DE TAMIS]
J. Valensi and J. Rebont (CNRS) In AGARD Aerodyn of Rotary Wings Feb 1973 14 p refs In FRENCH (For availability see N73-21031 12-02)

The effects of drag, lift, and pitching moments on a rectangular wing profile system were measured. Measurements were taken at different incidences and different values of advancement parameters. Transl. by E.H.W.

N73-21044* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A COMPRESSIBLE UNSTEADY THEORY FOR HELICOPTER ROTORS
Charles E. Hammond and G. Alvin Pierce (Ga. Inst. of Tech.) In AGARD Aerodyn of Rotary Wings Feb 1973 15 p refs Prepared in cooperation with Army Air Mobility Res. and Develop. Lab., Ft. Eustis, Va. (For availability see N73-21031 12-02) (Contract DAHC04-68-C-0004)

An aerodynamic theory is presented which allows the determination of the unsteady aerodynamic loading on a reference section of a helicopter rotor blade in axial or hovering flight under compressible flow conditions. The aerodynamics of the two-dimensional flow model are formulated using a kernel function approach. By introducing the acceleration potential the governing integral equation for the flow and its attendant downwash boundary condition are developed and solved numerically using

a pressure mode assumption and a collocation technique The compressible aerodynamic theory thus developed is compared analytically with two other existing theories, one incompressible and one compressible, and is shown to agree with these theories provided that the appropriate limit is taken so that the flow models agree The ratio of blade oscillatory frequency to rotor rotational frequency is shown to be the correlation parameter between the two flow models Author

N73-21045 Messerschmitt-Boelkow-Blohm G m b H , Ottobrunn (West Germany)

SOME ASPECTS OF THE DESIGN OF ROTOR-AIRFOIL SHAPES

G Reichert and S N Wagner *In* AGARD Aerodyn of Rotary Wings Feb 1973 22 p refs (For availability see N73-21031 12-02)

Analytical studies have shown that performance, stability and control of helicopters can be improved if some characteristics of rotor airfoils could be changed Starting from given airfoil shapes the characteristics of these airfoils are idealized by changing lift curve slope, maximum lift boundary and beginning of drag divergence The influences of these changes on the power required, the stability and control of hingeless rotor helicopters are studied Furthermore, the desirable characteristics of an airfoil or several airfoils of a rotor are defined using these idealized characteristics and analysing common missions of a given helicopter Similar studies of a larger field of missions and helicopters could lead to new areas of research and development to design advanced profile shapes of helicopters of the future Several analytical tools for the design of airfoils are discussed Author

N73-21046 Army Air Mobility Research and Development Lab , Moffett Field, Calif

RECENT DEVELOPMENTS IN ROTOR BLADE STALL

W J McCroskey *In* AGARD Aerodyn of Rotary Wings Feb 1973 13 p refs (For availability see N73-21031 12-02)

Developments in techniques for analyzing boundary layers of rotary wings are discussed The basic effects of rotation and crossflow due to forward flight have been identified and found to be insignificant for most cases of practical interest in helicopter aerodynamics Within the framework of classical thin boundary theory, unsteady viscous effects are also small Unsteady viscous-inviscid interaction appears to play an important role in retreating blade stall The characteristics of retreating blade stall are described based on vortex like disturbance from the leading edge of the rotor blade Author

N73-21047 Royal Aircraft Establishment, Farnborough (England)

THE DERIVATION AND VERIFICATION OF A NEW ROTOR PROFILE ON THE BASIS OF FLOW PHENOMENA, AEROFOIL RESEARCH AND FLIGHT TESTS

H H Pearcey, P G Wilby, M J Riley, and P Brotherhood *In* AGARD Aerodyn of Rotary Wings Feb 1973 18 p refs (For availability see N73-21031 12-02)

An account is given of some of the considerations that governed the derivation of new profiles to be incorporated in the design of the rotor blades for the Lynx helicopter at its inception The changes relative to the NACA 0012 profile were conservative but were chosen to give consistent and significant all-round improvements to the shock-induced limits on the advancing blade to the retreating-blade thrust limits and to the loading that could be sustained without shock wave drag in hover The conservatism applied especially to the stalling characteristics which play such a dominant part in limiting rotor performance but which are so difficult to predict for the rotor environment The profiles were derived on the basis of steady flow aerofoil tests but qualitatively similar improvements have been verified in oscillatory aerofoil tests and in flight A technique used in the latter tests is described for measuring pressure distributions along the blade chord and across the blade wake in the region of the rotor tip in flight Author

N73-21048 Army Air Mobility Research and Development Lab , Moffett Field, Calif

THE EFFECT OF PLANFORM SHAPE ON THE TRANSONIC FLOW PAST ROTOR TIPS

W F Ballhaus and F X Caradonna *In* AGARD Aerodyn of Rotary Wings Feb 1973 12 p refs (For availability see N73-21031 12-02)

A numerical relaxation algorithm capable of calculating the transonic inviscid flow about arbitrary planform rotors has been developed The essential feature of this method is a transformation in which arbitrary planforms are converted to rectangles and all boundary condition problems are transferred to the equation of motion Preliminary numerical calculations are presented for blades of various sweeps and profiles It is seen that three-dimensional effects remove sweep effects and can cause shocks which are locally more severe than would occur in less swept or even unswept planforms The method presents itself as a means of checking various rotor configurations before any tests are made Author

N73-21049* National Aeronautics and Space Administration Ames Research Center, Moffett Field Calif

A SUMMARY OF WIND TUNNEL RESEARCH ON TILT-ROTORS FROM HOVER TO CRUISE FLIGHT

Ph Poisson-Quinton and W L Cook *In* AGARD Aerodyn of Rotary Wings Feb 1973 16 p refs (For availability see N73-21031 12-02)

An experimental research program conducted on a series of tilt rotors designed for a range of blades twist is reported The test facilities used in the program are identified The objective of the program was to obtain precise results on the influence of blades twist and aeroelasticity on tilt rotor performance from hover to high speed cruise Mach number to 0 7 Five aluminum rigid rotors and one fiber glass composite rotor were tested Author

N73-21050 Naval Ship Research and Development Center, Bethesda, Md

RECENT DEVELOPMENTS IN CIRCULATION CONTROL ROTOR TECHNOLOGY

Robert Williams *In* AGARD Aerodyn of Rotary Wings Feb 1973 19 p refs (For availability see N73-21031 12-02)

Research on the historical concept of circulation control applied to rotor blades is presented A high speed helicopter application is used to illustrate the potential of this rotor for a major breakthrough in the areas of rotor efficiency, parasite drag and weights leading to a large improvement in aircraft productivity Details of the hover, transition and high speed cruise performance are presented Some problems of autorotation, vibrations and blade dynamics are also discussed Author

N73-21051 Messerschmitt-Boelkow-Blohm G m b H , Ottobrunn (West Germany)

SOME OBJECTIVES IN APPLYING HINGELESS ROTORS TO HELICOPTERS AND V/STOL AIRCRAFTS

H B Huber *In* AGARD Aerodyn of Rotary Wings Feb 1973 16 p refs (For availability see N73-21031 12-02)

Some of the aerodynamic, dynamic and aeroelastic problems in rotor design for helicopters and V/STOL-aircraft are discussed After a short description of the main features of the hingeless rotor concept the most important research and design areas of the system are indicated Attention is given to the flapping and inplane stiffness of the blade root section, the aerodynamic and dynamic blade design, the rotor hub geometry and the control system flexibility The aeroelastic characteristics and some important parameter sensitivities are reported The analytical and experimental studies include control and flight dynamic characteristics, structural loads, damping behaviour and aeroelastic stability Analytical results are compared with test data Based on these results some design criteria are provided and recommendations are made for a successful application of hingeless rotor systems on helicopters and tilting prop/rotor aircrafts Author

N73-21052 SIAI Marchetti S p A Varese (Italy)

AERODYNAMICS OF HELICOPTER COMPONENTS OTHER THAN ROTORS

Angelo Bosco *In* AGARD Aerodyn of Rotary Wings Feb 1973 16 p refs (For availability see N73-21031 12-02) (Contract DAJA37-72-C-1998)

The effects of parameters other than rotary wings on the performance of helicopters are discussed Specific examples for the design of the SV-20A winged helicopter are presented Wind tunnel tests to isolate aerodynamic interferences and to confirm aerodynamic analyses are described The application of nonrotating component aerodynamics to optimization of the helicopter design is reported Author

N73-21063* Loughborough Univ of Technology (England)
FUNDAMENTAL CONSIDERATION OF NOISE RADIATION BY ROTARY WINGS
Martin V Lowson *In* AGARD Aerodyn of Rotary Wings Feb. 1973 18 p refs Sponsored by NASA and Natl Gas Turbine Estab. (For availability see N73-21031 12-02)

An historical review of progress in understanding of rotor noise is presented Initial work was principally on propellers, but has many obvious applications to noise from rotary wings Current understanding of rotor noise radiation is then reviewed in some detail The principal noise sources appear to be (1) discrete frequency due to distorted inflow, (2) low frequency broadband due to turbulent inflow, and (3) high frequency broadband due to tip effects On a helicopter rotor each of these sources seems to be intimately connected with the shed vortex wakes Tip modifications offer one method for controlling the effects The implications for the designer are discussed Rotor subjective noise levels appear to obey a velocity to the eighth power law, independent of thrust Experiments to rectify some of the present deficiencies in knowledge are suggested Author

N73-21064 Bogazici Univ., Istanbul (Turkey)
WAKE CHARACTERISTICS OF A TWO DIMENSIONAL ASYMMETRIC AEROFOIL
Ibrahim Kavrak *In* AGARD Aerodyn Rotary Wings Feb 1973 7 p refs (For availability see N73-21031 12-02)

The process by which dipole noise is generated by the turbulent wake behind an airfoil is discussed The characteristics of the wake are investigated and compared to the drag and lift coefficients as well as the noise radiated It is concluded that both the drag coefficient and the generated noise are closely related to the turbulent shear in the separated flow area The maximum velocity defect is shown to be an important parameter which affects both the performance and the noise intensity Author

N73-21065 Societe Nationale Industrielle Aerospatiale, Marseille (France)
MEASURE OF HELICOPTER NOISE DURING FLIGHT [MESURES DE BRUIT D'HELICOPTERES EN VOL]
Fernand DAmbra, Jean-Pierre Dedieu, and Alain Julienne (ONERA, Chatillon, France) *In* AGARD Aerodyn of Rotary Wings Feb 1973 15 p refs In FRENCH; ENGLISH summary (For availability see N73-21031 12-02)

Noise measurements have been performed on several helicopters. These tests were aimed toward a complete survey of helicopters' internal and external noise levels in several flight conditions Data analysis of flyover tests follows conventional aircraft's acoustical certification procedure Test results are corrected to duplicate nominal flight path and standard atmosphere conditions in several noise units A statistical analysis of maximum noise levels has been performed and results are presented with their confidence level. The use of the trajectography equipment grants in addition the exact timing of acoustical spectra from which directivity patterns of noise radiated from the complete aircraft in flight and from particular noise sources can be obtained Author

N73-21066 Westland Helicopters, Ltd, Yeovil (England)
THE NOISE CHARACTERISTICS OF A LARGE CLEAN ROTOR
John W Leverton *In* AGARD Aerodyn of Rotary Wings Feb 1973 14 p refs (For availability see N73-21031 12-02)

A 2-bladed 56-ft diameter rotor was run on a tower in an inverted mode so that the problem of recirculation and the difficulties of measuring noise directivity characteristics could be overcome This paper outlines the analysis procedure used and presents the detailed results obtained From a practical point of view rotor noise can be considered to consist of rotational or discrete frequency noise, low frequency broadband noise and high frequency broadband noise The spectrum characteristics and the directivity patterns of each of these sources have been examined as a function of the blade tip speed, the total rotor thrust and the measurement angle relative to the rotor disc plane The trends associated with the overall noise, which is dependent on the relative magnitude of the individual sources, have also been studied These results have been compared, where possible, with the trends given by theoretical and semiempirical prediction methods Time history traces are also included, these show that even under ideal conditions rotor noise is impulsive in nature Author

N73-21920# Advisory Group for Aerospace Research and Development Paris (France)
HELICOPTER BLADE FLUTTER Revision of Part 3, Chapter 10 of AGARD Manual on Aeroelasticity
N D Ham (MIT, Cambridge) Jan 1973 37 p refs
(AGARD-R-607) Avail NTIS HC $4 00

Methods of analysis of helicopter blade flutter for both hinged and hingeless blades are presented The major types considered are bending-torsion flutter, flap-lag flutter, and stall flutter Both hover and forward flight are considered Means of avoiding flutter are described Author

N73-21931# Advisory Group for Aerospace Research and Development, Paris (France)
AERODYNAMICS OF ROTARY WINGS
Norman D Ham (MIT) Mar 1973 9 p refs Presented at Fluid Dyn Panel Specialists Meeting, Marseille, 13-15 Sep 1972
(AGARD-AR-61; AGARD-CP-111) Avail NTIS HC $3 00

The proceedings of a conference to discuss the aerodynamics of rotary wings are presented The subjects discussed are (1) rotor wakes, (2) rotors at hover and at high advance ratio, (3) rotor unsteady airloads (4) rotor airfoils, (5) rotor configurations, and (6) noise generated by rotary wings P.N.F.

N73-24042# Advisory Group for Aerospace Research and Development, Paris (France)
AIRCRAFT PERFORMANCE: PREDICTION METHODS AND OPTIMIZATION
J Williams, ed Mar 1973 345 p refs In ENGLISH and partly in FRENCH
(AGARD-LS-56) Avail NTIS HC $19 25

The development and application of aircraft performance prediction methods are developed The methods are applied to subsonic and supersonic aircraft The basic topics discussed include (1) range and radius capabilities, (2) takeoff and landing operations, and (3) aircraft maneuvers Problems of aerodynamic prediction, aircraft mass estimation, and engine selection are included Parametric and optimization techniques for aircraft design synthesis are reported For individual titles, see N73-24043 through N73-24054

N73-24043 Ministry of Defence, London (England) Project Performance Analysis Section
RANGE AND RADIUS-OF-ACTION PERFORMANCE PREDICTION FOR TRANSPORT AND COMBAT AIRCRAFT
Robert K Page *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 32 p refs (For availability see N73-24042 15-02)

Numerical methods for determining the range and radius of action performance of transport and combat aircraft are presented The data required for the prediction process are explained Conditions which govern the choice of method to be used are analyzed The following parameters are examined to show the effect on aircraft range (1) optimum cruising speeds, (2) cruise height schedules and integrated range, (3) effect of various aircraft and engine characteristics Mathematical models are included to support the theoretical concepts and tables of data are provided to show application of data Author

N73-24044 Royal Aircraft Establishment, Farnborough (England). Aerodynamics Dept
AIRFIELD PERFORMANCE PREDICTION METHODS FOR TRANSPORT AND COMBAT AIRCRAFT
John Williams *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 56 p refs (For availability see N73-24042 15-02)
Methods for evaluating and predicting the airfield performance of turbojet and turbofan aircraft operating in conventional and short takeoff modes are developed Airfield performance parameters include (1) accelerating and decelerating ground run, (2) rotation to liftoff and from touchdown, (3) airborne flare, up and out, and (4) climb and descent approach The aircraft configurations to which the data apply are described The factors involved in airfield performance prediction are formulated separately for takeoff and landing operations The sensitivity of airfield performance comparisons to the specific choice of technical and operational assumptions is illustrated Author

N73-24045 Dornier-Werke G m b H , Friedrichshafen (West Germany) Flight Mechanics Dept
FLIGHT MANOEUVRE AND CLIMB PERFORMANCE PREDICTION
Heribert Friedel *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 51 p refs (For availability see N73-24042 15-02)
Methods for predicting aircraft flight maneuver and climb performance are presented The methods are based on the equations of motion in a vertical and in a horizontal plane The problems concerning the point performance values are explained The relationship between excess power and load factor and their influence on climb and turn performance are discussed Methods for evaluating the Mach-dependent performance values and the related optimum values are reported Author

N73-24046 Service Technique Aeronautique, Paris (France)
THE ESTIMATION OF AERODYNAMIC COEFFICIENTS NECESSARY FOR PERFORMANCE CALCULATIONS
C Lievens *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 28 p In FRENCH (For availability see N73-24042 15-02)
Aerodynamic coefficients are used to study the performance of scale and wind tunnel models of transport aircraft Data cover fuselage reactions, boundary layer evolution, and differences in results for the two models Particular attention was given to the effects of boundary layer flow separation, boundary layer evolution, boundary layer reaction near flight and attack edge, and shock wave interaction with the boundary layer
Transl by E H W

N73-24047 Service Technique Aeronautique, Paris (France)
AIRCRAFT MASS
C Vivier and P Cormier *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 21 p In FRENCH (For availability see N73-24042 15-02)
A study was made of methods used to estimate aircraft mass and the effects of that mass on the aircraft performance
Transl by E H W

N73-24048* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ENGINE SELECTION FOR TRANSPORT AND COMBAT AIRCRAFT
James F Dugan, Jr *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 55 p refs (For availability see N73-24042 15-02)
CSCL 21A
The procedures for selecting engines for transport and combat aircraft during the design process are presented The types of aircraft considered are (1) a long haul conventional takeoff and landing transport, (2) a short haul vertical takeoff and landing transport, (3) a long range supersonic transport, and (4) a fighter aircraft The influence of aircraft noise considerations on engine selection is examined The aerodynamic characteristics of supercritical wings and their effect on engine selection are reported Author

N73-24049 Boeing Co., Seattle, Wash. Commercial Airplane Div.
PARAMETRIC AND OPTIMISATION TECHNIQUES FOR AIRPLANE DESIGN SYNTHESIS
Richard E Wallace *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 57 p refs (For availability see N73-24042 15-02)
Aircraft design synthesis for various conditions of performance and load carrying capacity is discussed The subjects presented are (1) parametric evaluation techniques, (2) optimization evaluation techniques, and (3) computerized airplane design synthesis Charts are developed to show the elements of synthesis, principal lines of data flow for aircraft design, propulsion parameters, aerodynamic parameters, and optimization methods
Author

N73-24050 Societe Nationale Industrielle Aerospatiale, Paris (France)
DISCREPANCY BETWEEN APPROVAL AND MODERNISM
G Dumas *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 3 p (For availability see N73-24042 15-02)
The characteristics of aircraft flight manuals and their formats for presentation of information are discussed A specific example of the take-off performance chart is developed Discrepancies in performance data which arise from different methods of compiling and computing the information are cited A diagram of a typical takeoff chart to show the interrelationships of outside air temperature, flap setting, aircraft weight, speed ratio, runway slope, and wind velocity and their effect on takeoff distance is included Author

N73-24051 Technische Hogeschool, Delft (Netherlands)
AN ANALYTICAL EXPRESSION FOR THE BALANCED FIELD LENGTH
E Torenbeek *In* AGARD Aircraft Performance Prediction Methods and Optization Mar 1973 8 p refs (For availability see N73-24042 15-02)
A tractable analytical expression for the balanced field length of a civil aircraft to be used in parametric design studies is presented It is demonstrated that in the project design stage, a detailed solution of the equations of motion and the graphical-numerical processes for the definition of the decision point can be avoided without serious loss of accuracy Mathematical models are prepared to show the method for analyzing aircraft takeoff performance Diagrams are included to show the phases of takeoff which influence the aircraft performance and forces exerted on the aircraft during the takeoff phases Author

N73-24052 Dornier-Werke G m b H Friedrichshafen (West Germany)
SUPPLEMENTARY NOTE TO FLIGHT MANOEUVRE AND CLIMB PERFORMANCE PREDICTION
P Foerster *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 8 p (For availability see N73-24042 15-02)
A numerical analysis of the minimum time climbing procedure for aircraft is presented The procedure is defined as the locus of all tangent points of the constant energy lines and the constant specific excess power lines on the performance chart In a similar manner, the minimum fuel climbing procedure is defined by a locus of all tangent points of the constant energy maneuverability index lines and the constant specific energy lines Specific application of the methods to a typical subsonic aircraft is analyzed Author

N73-24053 Hawker Siddeley Aviation Ltd Brough (England)
MINIMUM TIME TRAJECTORY COMPUTATION. DEVELOPMENT OF THE BALAKRISHNAN METHOD
P Middleton *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 6 p ref (For availability see N73-24042 15-02)
The development of a computer program for determining minimum time trajectory for aircraft flight is discussed In the method discussed, the state and control variables are considered at a number of discrete points and a path through the matrix of these values is computed for the solution The gradient method

of computation in which the equations of motion are integrated at each iteration is described Mathematical models and graphs are included to support the theoretical considerations Author

N73-24064 Royal Aircraft Establishment, Farnborough (England)
REVIEW OF TWO METHODS OF OPTIMIZING AIRCRAFT DESIGN
D L I Kirkpatrick *In* AGARD Aircraft Performance Prediction Methods and Optimization Mar 1973 p 14 (For availability see N73-24042 15-02)

Two methods of optimizing aircraft design are discussed One is an analytical method of optimizing three of the principal design variables of a subsonic swept wing jet transport aircraft and demonstrated how optimum design is affected by changes in mission requirements, operational constraints, and assumed design changes The other method uses an aircraft design program coupled with the multivariate analysis technique to optimize 15 aircraft design variables using equations to represent the aerodynamic characteristics of the wing and high-lift devices, the masses of all the various aircraft components, and the engine performance Author

N73-27000# Advisory Group for Aerospace Research and Development, Paris (France)
MILITARY APPLICATIONS OF V/STOL AIRCRAFT, VOLUME 1
Apr 1973 145 p refs Partly in ENGLISH and partly in FRENCH Presented at 41st meeting of the flight Mech Panel of AGARD, Brussels, 23-25 Oct 1972
(AGARD-CP-126-Vol-1) Avail NTIS HC $9 25

The proceedings of a conference on the military applications of V/STOL aircraft are presented Past developments on experimental V/STOL aircraft as well as current military doctrine and operational experience are discussed Ongoing and new development programs are reviewed to provide visibility to potential new capabilities Future military applications for V/STOL aircraft in terms of currently perceived operational requirements were analyzed For individual titles, see N73-27001 through N73-27013

N73-27001 Massachusetts Inst of Tech, Cambridge
A REVIEW OF PAST AGARD/NATO ACTIONS ON V/STOL AIRCRAFT AND THEIR APPLICATIONS
R H Miller *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 3 p (For availability see N73-27000 18-02)

The 1969 meeting was convened in order to review the results of an AGARD study, V/STOL Comparison Study, conducted by an ad hoc group of specialists in late 1968 and 1969 and published as AGARD Advisory Report No 18 This study reviewed the status of existing technology, giving details of the many VTOL vehicles which had been built and the lessons learned from their flight experiences The report then reviewed the manner in which further research could be expected to increase the effectiveness of such vehicles and the potential mission improvements which would result The missions considered were attack, transport and rescue Finally a research program was outlined which hopefully would ensure achieving these improvements Author

N73-27002 Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France)
WIND TUNNEL FOCUSING POINT STUDY AND FLIGHT TEST OF ASSULT MIRAGE 3 5 [ETUDE ET MISE AU POINT EN SOUFFLERIE ET EN VOL DE L'AVION DASSAULT MIRAGE 3 5]
G DeRichemont *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 15 p In FRENCH (For availability see N73-27000 18-02)

Flight transition and control problems of the Mirage 3 (5) attack aircraft are studied during flight and in wind tunnels Data cover flight variations caused by exhaust, longitudinal skidding effects, and lift A comparison was made of test results Transl by E H W

N73-27003 Air Force Flight Dynamics Lab, Wright-Patterson AFB, Ohio Prototype Div
A REVIEW OF THE US TRI-SERVICE V/STOL PROGRAMS
Bernard Lindenbaum and Daniel E Fraga *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 17 p refs (For availability see N73-27000 18-02)

A brief history of the U S Tri-Service V/STOL Programs is presented and aspects of propeller-based propulsion systems for VTOL aircraft as represented by the three distinctly different design concepts found in the XC-142A, X-19 and X-22A are examined. A comparison of the basic characteristics of these aircraft is provided in hover and vertical flight, transition and STOL flight and flight in the conventional mode This includes a discussion of vehicle performance and efficiencies, handling qualities, and method of flight control In addition a summary of the major accidents associated with these programs is presented as well as a brief discussion of the impact of technology improvements on future propeller driven VTOL designs Author

N73-27004 Dornier-Werke G m b H, Friedrichshafen (West Germany)
DO 31 EXPERIMENTAL PROGRAM: RESULTS AND CONCLUSIONS OBTAINED AND FUTURE OUTLOOK [PROGRAMME EXPERIMENTAL DO 31: RESULTATS OBTENUS ET CONCLUSIONS A TIRER POUR L'AVENIR]
Radoslav Draganow and Heinz Max *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 15 p refs In FRENCH (For availability see N73-27000 18-02)

The technical aspects of the Dornier 31 V/STOL aircraft and the research project leading to production of the aircraft are discussed The following problems of V/STOL aircraft operation are discussed (1) control of the engine system, (2) stability and control in hover and transition, (3) jet interference effects, (4) recirculation and ground erosion effects, and (5) noise problems Author

N73-27005 Marine Aircraft Wing (2d), Cherry Point N C
AV-8A HARRIER CONCEPT AND OPERATIONAL PERFORMANCE, US MARINE CORPS
T H Miller, Jr and C M Baker (Marine Aircraft Group 32, Beaufort, S C) *In* AGARD Mil Appl of V/STOL Aircraft Vol 1 Apr 1973 6 p (For availability see N73-27000 18-02)

The design concept and operational performance of the AV 8a Harrier aircraft are discussed An analysis of the U S Marine Corps requirements and employment of the aircraft for military purposes is presented The use of V/STOL aircraft in various military situations is reported Author

N73-27006 Vereinigte Flugtechnische Werke G m b H Bremen (West Germany)
VAK 191 B EXPERIMENTAL PROGRAM FOR A V/STOL STRIKE-RECCE AIRCRAFT
Rolf Riccius and Werner Sobotta *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 18 p refs (For availability see N73-27000 18-02)

The design, development, and flight characteristics of the VAK 191b strike/reconnaissance aircraft are presented The subjects discussed are (1) research and development test program, (2) control systems, (3) longitudinal response, (4) hovering and vertical flight path characteristics, (5) flight control system transition characteristics, and (6) growth potential Author

N73-27007 Canadair, Ltd, Montreal (Quebec)
TESTING AND EVALUATION OF THE CANADAIR CL-84 TILT WING V/STOL AIRCRAFT
F C Phillips *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 13 p refs (For availability see N73-27000 18-02) Avail NTIS

The testing and evaluation of the CL 84 tilt wing V/STOL aircraft are discussed The subjects presented are (1) the CL-84 prototype program, (2) evaluation program (3) operational experience (4) application to specific military roles and (5) instrument flying evaluation Author

N73-27008 Avions Marcel Dassault, Saint-Cloud (France)
EXPERIENCE ACQUIRED DURING THE COURSE OF

FLIGHT TESTS AND OPERATIONAL UTILIZATION OF BREGUET 941 STOL AIRCRAFT [EXPERIENCE ACQUISE AU COURS DES ESSAIS EN VOL ET EN UTILISATION OPERATIONNELLE DE L'AVIONS STOL BREGUET 941]
J. Czinczenheim *In* AGARD Mil. Appl of V/STOL Aircraft, Vol 1 Apr 1973 12 p refs In FRENCH (For availability see N73-27000 18-02)
The history and performance principles of the Berguet 941 STOL aircraft are presented Problems encountered during the course of flight tests and solutions adopted are given Test data cover handling qualities, operational characteristics, rolling stability on the ground, and flight qualities Transl by E H W

N73-27009* National Aeronautics and Space Administration, Washington, D C
NASA PROPULSIVE LIFT STOL TECHNOLOGY PROGRAM
Gerald G Kayten and William S Aiken *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 4 p (For availability see N73-27000 18-02)
CSCL 01C
A NASA propulsive-lift technology program for short takeoff aircraft is discussed In the propulsive-lift program, turbofan engine power is used to augment the lift of essentially conventional wings Potentially important applications of the propulsive lift developments for various aircraft operating conditions are reported It is stated that the objective of the program is to provide technical information on the design, development, operation, and regulation of propulsive-lift aircraft Author

N73-27010* De Havilland Aircraft Co , Ltd , Downsview (Ontario)
THE BUFFALO/SPEY JET-STOL RESEARCH AIRCRAFT
D C Whittley *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 13 p refs Sponsored in part by NASA (For availability see N73-27000 18-02)
CSCL 01C
The program to design and build a Buffalo/Spey Augmentor-Wing research aircraft is presented The development of an internally blown flap system for the generation of powered lift is discussed Modification, development and testing of the Rolls-Royce Spey engine are reported The ground tests and first flights of the aircraft are described and the application of the internally blown flap concept for short takeoff military transport aircraft is proposed Author

N73-27011 British Aircraft Corp Weybridge (England)
MILITARY ASPECTS OF CIVIL V/STOL AIRCRAFT
N W Boorer *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 12 p ref (For availability see N73-27000 18-02)
The rationale of developing a military tactical short takeoff transport aircraft in an evolutionary pattern in parallel with the development of civil short takeoff aircraft is presented The main characteristics of military and civil short takeoff aircraft are described The military requirements and operational considerations of the short takeoff transport aircraft are defined Author

N73-27012 Aeronautical Systems Div , Wright-Patterson AFB, Ohio
SELECTING A STOL TRANSPORT
Fred D Orazio, Sr *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 9 p refs (For availability see N73-27000 18-02)
The procedures for identifying the proper characteristics of a short takeoff transport aircraft using current and past development efforts are discussed The procedures include (1) feasible designs incorporating powered/lift systems (2) advanced systems (including composite structures), (3) high flotation landing gears, (4) vulnerability protection, (5) operating margins and criteria, (6) aircraft handling qualities, (7) operating constraints, and (8) costs Author

N73-27013 Bundesminister fuer Verteidigung Bonn (West Germany)
GERMAN COMMENTS ON FUTURE V/STOL REQUIREMENTS
Uwe Koester *In* AGARD Mil Appl of V/STOL Aircraft, Vol 1 Apr 1973 2 p (For availability see N73-27000 18-02)
A survey of the V/STOL weapon system developments in Germany or with German participation is presented The rationale for developing short takeoff rather than vertical takeoff aircraft is developed Problems involved in the engineering of short takeoff aircraft are described The reasons for not formulating concrete military requirements for short takeoff aircraft are enumerated Author

N73-27895# Advisory Group for Aerospace Research and Development, Paris (France)
INFLUENCE OF PILOT AND AIRCRAFT CHARACTERISTICS ON STRUCTURAL LOADS IN OPERATIONAL FLIGHT
J R Sturgeon May 1973 29 p refs
(AGARD-R-608) Avail NTIS HC $3 50
Some aircraft handling problems met in operational conductions are described and compared with flight test conditions It is concluded that errors in flight instrumentation and physiological cues have a substantial influence on control capability A unified strategy for flight in all operational conditions is required to reduce these problems A strategy, aimed at minimising structural loads and aerodynamic problems in all flight conditions, is proposed that will restore to pilot and autopilot flying the positive stability in pitch and yaw which is a classic requirement for aircraft operating in the stick free mode Proposals are made for improving the requirements of flight instruments to reduce control problems during complex maneuvres and flight in severe wind shear conditions Author

N73-27906# Advisory Group for Aerospace Research and Development, Paris (France)
V/STOL HANDLING-QUALITIES CRITERIA. PART 2: DOCUMENTATION
Jun 1973 88 p refs
(AGARD-R-577-Pt-2) Avail NTIS HC $6 50
The factors which affect the handling characteristics of V/STOL aircraft are discussed The criteria are based on several sources of information to include (1) analytical studies, (2) piloted simulator tests (3) flight tests, and (4) specially equipped variable stability aircraft and helicopters The results of the tests involving handling and stability are presented in tabular form Author

N73-31954# Advisory Group for Aerospace Research and Development, Paris (France)
ESCAPE MEASURES FOR COMBAT HELICOPTER CREWS
Aug 1973 39 p refs
(AGARD-AR-62) Avail NTIS HC $4 00
A study was conducted to determine the requirements and characteristics of escape systems for use with helicopters It was stated that escape systems are feasible but that the rotary wing creates the greatest obstacle to emergency seat ejection It was recommended that helicopter escape concepts be considered under the following categories (1) an escape system for retrofit into helicopters already in production or in service (2) an escape system for a near term solution and (3) an escape system for a far term solution The conclusion of the study was that a retrofittable escape system is practical only if it requires an absolute minimum of development time and does require major changes to the helicopter The only likely canidates to satisfy the requirement are manual bailout or sideward ejection Author

N74-10908# Advisory Group for Aerospace Research and Development, Paris (France)
SPECIALISTS MEETING ON HELICOPTER ROTOR PREDICTION METHODS
Aug 1973 150 p refs Mostly in ENGLISH, partly in FRENCH Conf held at Milan, 30 31 Mar 1973
(AGARD-CP-122, AGARD-CP-122) Avail NTIS HC $9 50

The proceedings of a conference on methods for predicting the dynamic loads on helicopter rotors are presented. The subjects discussed are (1) rotary wing design technology, (2) rotor system evaluation using helicopter flight simulation program, (3) load prediction methods for hingeless rotor helicopters, and (4) integrated rotor/body loads prediction. For individual titles, see N74-10909 through N74-10916

N74-10909 Kaman Aerospace Corp., Bloomfield, Conn.
ROTARY WING DESIGN METHODOLOGY
Andrew Z. Lemnios *In* AGARD Specialists Meeting on Helicopter Rotor Prediction Methods Aug. 1973 14 p refs (For availability see N74-10908 02-02)

A nonlinear aeroelastic blade loads analysis is described for calculating the coupled responses, airloads distributions, and performance of helicopter rotors. The analysis is divided into two major parts: (1) calculation of blade transient stability behavior by means of linearized, coupled equations of motion, (2) calculation of periodic blade dynamics and airloads distributions using fully coupled, nonlinear equations of motion. The analysis includes six response modes and two input control modes. The equations of motion include all nonlinear inertial coupling effects and nonlinear aerodynamic effects such as reverse flow, Mach number variations, large induced flow angles, unsteady aerodynamics, and variable inflow. Additional features to the analysis are the inclusion of feedback mechanical coupling among the assumed modes and the inclusion of springs and dampers for each mode. Author

N74-10910 Boeing Co., Philadelphia, Pa. Structures Staff.
CURRENT LOADS TECHNOLOGY FOR HELICOPTER ROTORS
Richard Gabel *In* AGARD Specialists Meeting on Helicopter Rotor Prediction Methods Aug. 1973 11 p refs (For availability see N74-10908 02-02)

Prediction of fatigue design loads is essential for proper sizing of helicopter rotor systems. The C-60 rotor loads computer program is discussed. It incorporates the effects of airfoil section geometry, compressibility, stall, three dimensional flow, unsteady aerodynamics, and nonuniform inflow to provide reliable rotor loads for steady-state flight conditions even into the blade stall region. Rotor loads predictions are compared with actual flight test data from Boeing CH-47 and Model 347 helicopters. An approach to component sizing is presented in which a fatigue design loads histogram is constructed using calculated steady-state flight loads and empirically determined maneuver loads. Current efforts to improve rotor loads predictions through incorporation of fully coupled lag pitch flap routines, simulation of control system dynamics and development of maneuver loads programs are discussed. Author

N74-10911 Advisory Group for Aerospace Research and Development, Paris (France).
PREDICTION OF HELICOPTER ROTOR LOADS
J. Gallot *In its* Specialists Meeting on Helicopter Rotor Prediction Methods Aug. 1973 8 p refs In FRENCH; ENGLISH summary (For availability see N74-10908 02-02)

The correct design of a rotor requires quite a precise knowledge of the alternating loads to which blade and hub are submitted. The problem of the stress evaluation, from the early design stage, may lead very sophisticated methods, because the blade is operating in a very complex environment. Nevertheless simplified methods may give sufficiently precise results to set up correctly the dimensions of the main elements of the rotor. The method described here supposes simple aerodynamics, independent of blade elastic deformations. The degree of simplification achieved in this theoretical method seems to be justified by the correlation obtained with experimental airloads measured on a model rotor and stresses recorded on the same rotor or a full-scale semi-articulated rotor. Author

N74-10912 United Aircraft Corp., Stratford, Conn. Sikorsky Aircraft Div.
HELICOPTER ROTOR LOADS PREDICTIONS
Peter J. Arcidiacono and Raymond G. Carlson *In* AGARD Specialists Meeting on Helicopter Rotor Prediction Methods Aug. 1973 12 p refs (For availability see N74-10908 02-02)

A review is presented of the assumptions and techniques forming the basis for detailed computation of rotor loads. Typical correlation results showing the effects of variable inflow and unsteady aerodynamics on blade stresses and control loads are presented. These effects are shown generally to improve the accuracy of predicted results. A discussion of areas where further work can be expected to provide a stronger technical foundation for present analyses is presented. The principal areas include more detailed modeling of (1) the dynamic stall process, (to define unsteady drag, airfoil, and blade sweep effects), (2) blade lifting surface effects (to model more accurately blade-vortex interaction effects) and (3) airframe dynamics effects (to define more accurately the dynamic coupling between blade and hub motions). Author

N74-10913 Bell Helicopter Co., Fort Worth, Tex.
ROTOR SYSTEM DESIGN AND EVALUATION USING A GENERAL PURPOSE HELICOPTER FLIGHT SIMULATION PROGRAM
Richard L. Bennett *In* AGARD Specialists Meeting on Helicopter Rotor Prediction Methods Aug. 1973 15 p refs (For availability see N74-10908 02-02)

New helicopter rotor systems are designed and existing configurations are evaluated by means of a general purpose helicopter flight simulation computer program. Discussed in this paper are both the analysis incorporated in the program and examples of the results obtained from the program. The three major parts of the analysis are: (1) mathematical model of an elastic rotor based on the modal technique, (2) rotor aerodynamics, and (3) basic rigid vehicle flight mechanics. The interrelationship among these three parts are discussed. The program has been used in support of the following phases of rotor system design and evaluation: (1) rotor blade frequency placement, (2) wind tunnel simulation, (3) steady state flight simulation, and (4) transient or maneuvering flight simulation. Author

N74-10914 Westland Helicopters, Ltd., Yeovil (England).
THE PREDICTION OF LOADING ACTIONS ON HIGH SPEED SEMI-RIGID HELICOPTERS
K. T. McKenzie and D. A. S. Howell *In* AGARD Specialists Meeting on Helicopter Rotor Prediction Methods Aug. 1973 19 p refs (For availability see N74-10908 02-02)

The analytical techniques employed to predict the primary loading actions of a high speed semi-rigid rotor helicopter are described. The loading actions considered are overall aircraft trim balance, oscillatory rotor loading and vibratory forcing of the airframe. Some of the design considerations associated with each of these loading actions and the correlation with flight test analysis are presented. A description is given of a technique for the analysis of flight test results which has enabled a detailed comparison of the harmonic response of individual modes to be made. Author

N74-10915 Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
LOADS PREDICTION METHODS FOR HINGELESS ROTOR HELICOPTERS
G. Reichert *In* AGARD Specialists Meeting on Helicopter Rotor Prediction Methods Aug. 1972 12 p refs (For availability see N74-10908 02-02)

The special loading condition of the hingeless rotor helicopter is discussed. For the prediction of the loads, the aeroelastic behaviour of the rotor blades including characteristic coupling effects has to be considered. To determine the properties of the hingeless rotor system in an analytical approach, a mathematical model can be used, which simulates the aerodynamic and dynamic behaviour adequately. There is good experience with an aerodynamically and dynamically equivalent system of an articulated

rotor with high hinge offset. Analytical data as well as flight test data will be shown for different flight conditions including maneuvers. There is relatively good correlation. The loads necessary for the structural design of the rotor can be predicted reasonably well. The methods are not satisfactory for control loads in stalled conditions and for high harmonic vibratory loads. Author

N74-10816 Army Air Mobility Research and Development Lab., Moffett Field, Calif.
INTEGRATED ROTOR/BODY LOADS PREDICTION
R. M. Carlson and A. W. Kerr (Lockheed-Calif., Burbank) *In* AGARD Specialists Meeting on Helicopter Rotor Prediction Methods Aug. 1972 8 p refs (For availability see N74-10808 02-02)

An interdisciplinary analysis, which has grown out of a requirement for a nonlinear handling qualities evaluation tool, has been mechanized in a fashion which provides a capability to predict rotor loads affected by rotor/airframe interaction in steady-state and transient flight conditions. The modeling philosophy in developing this analysis combines the capabilities of a team of analysts from several specialties to create a versatile model which provides consistent data for numerous applications. This philosophy is presented in addition to a description of the model and a summary of its range of applications. Examples involving rotor loads prediction are presented: (1) evaluation of clearance between rotor blades and fuselage during extreme maneuvers, (2) estimation of four-bladed rotor reactionless inplane mode stability and loads, and (3) general maneuver capability and transient loads estimation. Also presented are areas proposed for continued development and refinement of the model to further increase [illegible] range of applications. Author

N74-12713# Advisory Group for Aerospace Research and Development, Paris (France).
MARKINGS FOR PROPELLER CONSPICUITY
T. C. D. Whiteside (RAF Inst. of Aviation Med.) Sep. 1973 17 p refs
(AGARD-AR-58) Avail: NTIS HC $3.00

The general problem of marking propellers so that they may be seen is discussed. The propeller must be conspicuous to persons walking near it when the aircraft is on the ground but, on the other hand, in taxiing and in flight it must not be distracting or annoying to the pilot. Other factors to be considered are the conspicuity at low and at high rpm; the conspicuity against various backgrounds since markings easily visible against a dark ground may not be visible against a light ground; the use of coloured markings which, although easily seen on a stationary propeller, become desaturated when the propeller is turning, and finally, the presence of brightness and of colour contrast with the background. In theory, to obtain maximal brightness contrast, black and white markings should be used so that the blades may be seen against either light and dark background. As black matt paint may appear grey since it scatters incident light, the markings should be in a gloss finish. Author

N74-17720# Advisory Group for Aerospace Research and Development, Paris (France).
FLIGHT IN TURBULENCE
Nov 1973 366 p refs Presented at the 42d Meeting of the Flight Mech. Panel of AGARD, Woburn Abbey, England, 14-17 May 1973
(AGARD-CP-140) Avail: NTIS HC $21.25

The proceedings of a conference on the effects of atmospheric turbulence on aircraft operation are presented. The subjects discussed include the following: (1) characteristics of atmospheric turbulence, (2) aircraft operational problems created by atmospheric turbulence, (3) analysis of wake vortices and wind shear, (4) structural loads and gust criteria, (5) aircraft design for performance under turbulent conditions, and (6) application of energy management concepts to flight path control in turbulence. For individual titles, see N74-17721 through N74-17746.

N74-17721* Meteorological Office, Bracknell (England).
TURBULENCE AT MEDIUM AND HIGH FLIGHT LEVELS
S. G. Comford *In* AGARD Flight in Turbulence Nov. 1973 14 p refs (For availability see N74-17720 09-02)

The characteristics of atmospheric turbulence at medium and high flight levels are discussed. Emphasis is placed on research on turbulence in clear air away from mountains and local storms and in clear air near storm tops. Estimates on the likelihood of encountering cloud and precipitation at the cruising levels of supersonic transport aircraft. Numerical forecasting techniques for atmospheric turbulence are reported. Author

N74-17722* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PROBLEMS IN THE SIMULATION OF ATMOSPHERIC BOUNDARY LAYER FLOWS
George H. Fichtl *In* AGARD Flight in Turbulence Nov. 1973 14 p refs (For availability see N74-17720 09-02)

The realistic simulation of flow in the atmospheric boundary layers at heights greater than two kilometers is discussed. Information concerning horizontally homogeneous and statistically stationary atmospheric boundary layer flows is presented. The problems related to the incorporation of the information into atmospheric wind simulation programs are analyzed. The information which the meteorologist must acquire in order to provide a basis for improving the simulation of atmospheric boundary flows is explained. Author

N74-17723 National Aeronautical Establishment, Ottawa (Ontario). Flight Research Lab.
TURBULENCE AND MESOSCALE HORIZONTAL TEMPERATURE GRADIENTS IN THE LOWER STRATOSPHERE
Ian MacPherson *In* AGARD Flight in Turbulence Nov. 1973 15 p refs (For availability see N74-17720 09-02)

Data are presented on the frequencies of occurrence of turbulence and significant horizontal temperature gradients along with their dependence on altitude, season, underlying terrain, geographical location, and jet stream position. These factors are important both in the forecast problem and in the comparison of these results with those of other observing programs. Specific examples of encounters with atmospheric turbulence during the course of a research project on atmospheric instability are provided. Author

N74-17724 Tennessee Univ. Space Inst., Tullahoma.
REVIEW OF DATA AND PREDICTION TECHNIQUES FOR WIND PROFILES AROUND MANMADE SURFACE OBSTRUCTIONS
Walter Frost *In* AGARD Flight in Turbulence Nov. 1973 18 p refs (For availability see N74-17720 09-02)
(Contract NAS8-27387)

A review of experimental data and analytical models related to flow over bluff obstacles is presented to provide a survey of basic flow theory available to analyze atmospheric wind patterns and man-made surface obstructions. Primary emphasis is placed on the distortion of shear flows approaching and passing over buildings or bluff surfaces such as fences or steps. The various physical phenomena of pressure and velocity variation in the

separated flow regions surrounding the body, velocity profiles in the displaced flow over the body, and the origin and decay of induced turbulence along the boundaries of the separated regions are described. Author

N74-17725 Delft Univ. of Technology (Netherlands). Dept. of Aeronautical Engineering.
PROGRESS IN THE MATHEMATICAL MODELLING OF FLIGHT IN TURBULENCE
O. H. Gerlach, G. A. J. VandeMoesdijk, and J. C. VanderVaart *In* AGARD Flight in Turbulence Nov. 1973 38 p refs (For availability see N74-17720 09-02)

Problems of mathematical modelling of aircraft flight in turbulence are discussed. The simulation of flight in the lower atmosphere during the approach and landing portions of the flight are emphasized. The discrepancy between the usual Gaussian representation of atmospheric turbulence and the actual non-Gaussian atmosphere is analyzed. A parameter is introduced to characterize the actual turbulence sensed by the pilot. A method is presented for finding the range of altitudes at which the most significant disturbances are encountered during the approach. Author

N74-17726 British Overseas Airways Corp., London (England).
BOAC EXPERIENCE WITH TURBULENCE
Ernest Chambers *In* AGARD Flight in Turbulence Nov. 1973 13 p (For availability see N74-17720 09-02)

The effectiveness of airborne radar in giving adequate warning of convective turbulence in clouds is discussed. Some encounters with turbulence in clear air are described and matters relating to the forecasting, reporting, and dissemination of turbulence occurrence are presented. The development of an airborne clear air turbulence detector is recommended and the performance requirements of the detector are developed. Problems with low level wind shear are also examined. Author

N74-17727 Deutsche Lufthansa Aktiengesellschaft, Frankfurt am Main (West Germany). Meteorological Dept.
AN AIRLINE'S EXPERIENCE ON TURBULENCE
Heinz Dreyling *In* AGARD Flight in Turbulence Nov. 1973 7 p (For availability see N74-17720 09-02)

A compilation of the replies of airline pilots to a questionnaire on different areas concerned with atmospheric turbulence is presented. An assessment is made on flight times in turbulence, strength and type of turbulence, and the potential effect of turbulence on airline operations. Specific geographical areas as well as airports with specific turbulence encounters are listed, and potential energy sources are mentioned. The turbulence penetration speed is discussed as well as means to avoid turbulent encounters or to alleviate turbulent conditions through air traffic control, meteorological reports, or pilot experience. Author

N74-17728 Royal Aircraft Establishment, Farnborough (England).
INFLUENCE OF PILOT AND AIRCRAFT CHARACTERISTICS ON STRUCTURAL LOADS IN OPERATIONAL FLIGHT
J. R. Sturgeon *In* AGARD Flight in Turbulence Nov. 1973 24 p refs Presented at the 35th Meeting of the Struct. and Mater. Panel, Toulouse, France, 24-29 Sep. 1972 (For availability see N74-17720 09-02)
(AGARD-608)

Some aircraft handling problems met in operational conditions are described and compared with flight test conditions. It is concluded that errors in flight instrumentation and physiological cues have a substantial influence on control capability. A procedure for minimizing structural loads and aerodynamic problems in all flight conditions is proposed. The procedure will restore to the pilot and to the autopilot controlled flying the positive stability in pitch and yaw which is required for aircraft operating in the stick free mode. Proposals are made for improving the requirements of flight instruments to reduce control problems during complex maneuvers and flight in severe wind shear conditions. Author

N74-17729 British Aircraft Corp., Warton (England). Military Aircraft Div.
AIRCRAFT RESPONSE TO TURBULENCE-CREW COMFORT ASSESSMENTS USING POWER SPECTRAL DENSITY METHODS
Brian Young *In* AGARD Flight in Turbulence Nov. 1973 9 p refs (For availability see N74-17720 09-02)

The effects of atmospheric turbulence on the efficiency of a flight crew are analyzed. The factors are identified as (1) atmospheric turbulence levels, (2) the characteristics of the aircraft in responding to turbulence, including the effects of structural modes, and (3) the tolerance of the crew to the level and duration of vibration at the crew station. The use of power spectral density techniques for assessing crew ride comfort is explained. In addition to defining aircraft response in both vertical and lateral turbulence, it is possible to include the effects of structural modes, assess the effects of autostabilization, and include crew proficiency degradation as a parameter in operational studies. Author

N74-17730 Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany).
THE EFFECT OF GUSTS AND WIND SHEAR FOR AUTOMATIC STOL APPROACH AND LANDING
Gunther Schaenzer *In* AGARD Flight in Turbulence Nov. 1973 17 p refs (For availability see N74-17720 09-02)

The characteristics of a flight control system for short takeoff aircraft are discussed. The system is used during steep and curved approaches. The system was simulated and flight tested during more than 500 automatic STOL approaches and landings. The effects of gusts and wind shear, especially at extremely low indicated airspeeds during approach and flare, with respect to the pilot's workloads, passenger comfort, throttle activity, angle of attack measurement, and precision in approach and landing are analyzed. Author

N74-17731 Transportation Systems Center, Cambridge, Mass.
THE DETECTION OF AIRCRAFT WAKE VORTICES
Ralph D. Kodis *In* AGARD Flight in Turbulence Nov. 1973 9 p refs (For availability see N74-17720 09-02)

The hazards created by the trailing vortices deposited in the wakes of heavy jet aircraft are discussed. In the terminal area this hazard leads to longer separation standards and reduced runway capacity. In order to shorten the required separations without compromising safety it is necessary to be able to detect the presence and motion of vortices in regions where they constitute a threat. The sensing techniques that have been developed are reported. The characteristics of acoustic and wind pressure sensors for detecting vortices are described. Author

N74-17732 Federal Aviation Administration, Washington, D.C. Office of Systems Engineering Management.
WAKE VORTEX AVOIDANCE SYSTEM PROGRAM (WVAS)
Lawrence Langweil *In* AGARD Flight in Turbulence Nov. 1973 9 p refs (For availability see N74-17720 09-02)

A wake vortex avoidance system (WVAS) program is described. The objective of the program is to design and implement a ground based monitoring and predictive system at airports which will increase runway capacity by eliminating the need for larger separations between aircraft for safety from wake vortices. The program consists of three major tasks: (1) sensor development, (2) vortex behavior characterization and hazard definition, and (3) integration of these tasks into an overall system design. The meteorological factors which affect the performance of the proposed system are analyzed. Author

N74-17733* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
VORTEX WAKE RESEARCH
John A. Zalovcik and H. Earl Dunham, Jr. *In* AGARD Flight in Turbulence Nov. 1973 14 p refs (For availability see N74-17720 09-02)

NASA investigations of aircraft trailing vortices are reviewed. Results obtained in flight on vortex characteristics, such as decay of maximum velocity and vortex drift, are presented for distances behind a generating C-5 aircraft from 0.6 to 13.0 nautical miles. The lateral control activity of a CV 990 aircraft probing the vortices generated by the C-5 aircraft is illustrated and the effect of the C-5 aircraft configuration on this activity is indicated. Results are presented from near-field and far-field studies of accelerated

vortex dissipation through the use of various devices such as mass ejection, spoilers, vortex generators, and trailing drag devices. Author

N74-17734 Aeronautical Research Associates of Princeton, Inc., N.J.

ON TURBULENCE ENVIRONMENT AND DESIGN CRITERIA

John C. Houbolt *In* AGARD Flight in Turbulence Nov. 1973 15 p refs (For availability see N74-17720 09-02)

Aircraft design criteria based on the effects of atmospheric turbulence are discussed. Emphasis is placed on the power spectral techniques, but equivalences to the discrete-gust procedure are shown. Consideration is given to large design loads, such as limit load and to repeated loads which affect structural fatigue. Mathematical models are provided to illustrate the gust design approaches and the basic spectral procedure. Author

N74-17735 NATO MRCA Development and Production Management Agency, Munich (West Germany)

DESIGN PROBLEMS OF MILITARY AIRCRAFT AS AFFECTED BY TURBULENCE

M. Hacklinger *In* AGARD Flight in Turbulence Nov. 1973 9 p ref (For availability see N74-17720 09-02)

The influence of atmospheric turbulence on the design of military aircraft is analyzed. The subject is treated in two main categories (1) turbulence as a sizing factor in itself which determines static and fatigue strength of major parts of low load factor aircraft and (2) turbulence as an important design parameter of high load factor aircraft where stability of the augmented aircraft in manual or automatic terrain following flight, pilot proficiency under vibration, and the attitude accuracy of the aircraft as a weapons platform become important. The problem of designing for proper flight qualities in high speed tactical fighter missions is described with emphasis on analytical prediction of pilot task proficiency under the vibration environment created by airframe and flight control system characteristics. Author

N74-17736 Messerschmitt-Boelkow G.m.b.H., Ottobrunn (West Germany)

INFLUENCE OF TURBULENCE ON HELICOPTER DESIGN AND OPERATION

G. Reichert and M. Rade *In* AGARD Flight in Turbulence Nov. 1973 16 p refs (For availability see N74-17720 09-02)

The sensitivity of the helicopter to atmospheric turbulence because of the relatively low disc loading is discussed. The influences of other parameters such as rotor stiffness and damping are analyzed. The effects of these influences on different helicopters are compared. The main design problems of meeting operational and certification requirements and methods for improving the performance of helicopters are examined. Author

N74-17737 De Havilland Aircraft Co., Ltd., Downsview (Ontario)

DATA REQUIREMENTS ON TURBULENCE IN THE EARTH'S ATMOSPHERIC SHEAR LAYER FOR STOL DESIGN CRITERIA

J. J. Glaser *In* AGARD Flight in Turbulence Nov. 1973 8 p refs (For availability see N74-17720 09-02)

The factors which affect the airworthiness of short takeoff aircraft, especially during the landing and takeoff phase of the operation. Atmospheric turbulence is one of the most important factors affecting aircraft behavior at low altitudes, and its description in terms of a realistic model is an essential step in the design, certification, and operation of STOL aircraft. A study to devise a low altitude gust model and to determine the relative importance of the gust model parameters of the responses of typical STOL aircraft was conducted. The significant features of the DHC-3 aircraft which was used in the test are analyzed. Author

N74-17738 Hawker Siddeley Aviation Ltd., Hatfield (England)

EXPERIENCE WITH A LOW ALTITUDE TURBULENCE MODEL FOR AUTOLAND CERTIFICATION

R. M. P. McManus *In* AGARD Flight in Turbulence Nov. 1973 8 p ref (For availability see N74-17720 09-02)

The effects of atmospheric turbulence on the autoland system of the Trident aircraft are discussed. The aircraft was instrumented to obtain three axis gust time histories for each landing made. From these time histories a gust model was built up and was used for the initial certification of the automatic landing system. The results obtained with the gust model are compared with the statistical analysis of flight test data to determine the degree of correlation. Author

N74-17739 British Aircraft Corp., Weybridge (England). Commercial Aircraft Div.

STRUCTURAL LOADS AND GUST CRITERIA

D. O. N. James *In* AGARD Flight in Turbulence Nov. 1973 13 p refs (For availability see N74-17720 09-02)

The effects of atmospheric turbulence on aircraft design criteria are analyzed. The discrete gust methods are compared with the power spectral density methods to determine the degree of application to aircraft gust load problems. The application of continuous turbulence design procedure was investigated. Mission analysis results are shown to be very sensitive to the assumed operating technique. Graphs of specific aircraft design envelope limit loads against the discrete gust load limit are provided. Author

N74-17740 Royal Netherlands Aircraft Factories Fokker, Amsterdam

RATIONAL CALCULATION OF DESIGN GUST LOADS IN RELATION TO PRESENT AND PROPOSED AIRWORTHINESS REQUIREMENTS

J. Yff *In* AGARD Flight in Turbulence Nov. 1973 11 p refs (For availability see N74-17720 09-02)

An analysis of accurately calculated gust loads for three short haul aircraft was conducted. The results are applied to the following conditions (1) comparison of power spectral density and discrete gust methods, (2) comparison of power spectral density mission analysis and design envelope results, (3) comparison of power spectral density results for vertical and lateral gusts, and (4) a study of the specific problems of T-tail configurations. Graphs of load conditions for various aircraft components are provided. Author

N74-17741 British Aircraft Corp., Warton (England). Military Aircraft Div.

C.S.A.S. DESIGN FOR GOOD HANDLING IN TURBULENCE

A. G. Barnes *In* AGARD Flight in Turbulence Nov. 1973 14 p refs (For availability see N74-17720 09-02)

The design objectives for aircraft control and stability augmentation systems are discussed with respect to the effects of atmospheric turbulence. The subjects presented include the following (1) handling qualities requirements for flight in turbulence, (2) performance of unaugmented aircraft in turbulence, (3) performance of augmented aircraft in turbulence, and (4) approaches to stability augmentation systems development. Specific emphasis is placed on the aircraft parameters of planform, excitation derivatives, control power and aircraft size. Author

N74-17742* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

THEORETICAL HORIZONTAL TAIL LOADS AND ASSOCIATED AIRCRAFT RESPONSES OF AN AUTOPILOT-CONTROLLED JET TRANSPORT FLYING IN TURBULENCE

Boyd Perry, III and Kermit G. Pratt *In* AGARD Flight in Turbulence Nov. 1973 9 p refs (For availability see N74-17720 09-02)

An exploratory analytical study was conducted to analyze problem areas associated with a rigid aircraft controlled by a simple autopilot. The aircraft motion is constrained to the longitudinal phugoid and short period modes. The autopilot characteristics are described. The analytical procedure is explained and stabilizer loads together with some aircraft motions as functions of autopilot gains within the stability boundaries are determined. The effects of center of gravity location and altitude are considered. Author

N74-17743 Royal Aircraft Establishment, Farnborough (England) Avionics Dept.
THE DESIGN OF AUTOMATIC FLIGHT CONTROL SYSTEMS TO REDUCE THE EFFECTS OF ATMOSPHERIC DISTURBANCES
M. J. Corbin and K. F. Goddard *In* AGARD Flight in Turbulence Nov. 1973 16 p refs (For availability see N74-17720 09-02)

The design of two experimental automatic flight control systems for the BAC 111 aircraft is described. One system used throttle and elevator controls and the other uses, in addition, direct lift control by means of spoilers. The landing performance of the systems is compared with conventional automatic landing systems. It is stated that discrete gusts experienced at heights below 15 meters can produce large touchdown errors exceeding the capability of the autopilot control. Author

N74-1774/ Establishment, Bedford (England)
Aero F
APPLI [illegible] NAGEMENT CONCEPTS TO FL[illegible] URBULENCE
J [illegible] ight in Turbulence Nov 1973
1 [illegible] 74-17720 09-02)

[illegible] s of [illegible] on aircraft flight path control [illegible] outline is presented of a strategy for the control [illegible] nd flight path of an aircraft, based on the use of [illegible] ontrol total energy error, consisting of a kinetic [illegible] ated with airspeed and a potential component asso[illegible] and the elevator used to distribute the [illegible] rspeed and height in an optimum manner [illegible] the flight path control in a landing approach. The safety [illegible] ects of an aircraft subjected to large gust disturbances are also considered. Author

N74-17745 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
A NEW APPROACH TO GUST ALLEVIATION OF A FLEXIBLE AIRCRAFT USING AN OPEN LOOP DEVICE
Pierre-Marie Hutin *In* AGARD Flight in Turbulence Nov. 1973 9 p ref In FRENCH; ENGLISH Summary (For availability see N74-17720 09-02)

The application of optimization techniques for the purpose of gust alleviation is discussed. The basic approach is an extension of the Wiener's optimization theory to two control parameters and the application to the Caravelle aircraft. A comparison is made between the theoretical responses to a Gaussian stationary excitation and the responses to actual records of turbulence given by an analong computer taking into account the nonlinearities due to limited efficiency of the controls. Author

N74-17746 Royal Aircraft Establishment, Bedford (England)
SOME COMMENTS ON METHODS OF AVOIDING THE EFFECTS OF TURBULENCE
A. McPherson *In* AGARD Flight in Turbulence Nov. 1973 11 p refs (For availability see N74-17720 09-02)

The characteristics of airborne detectors for warning of the presence of clear air turbulence are discussed. The turbulence problem and the effects of atmospheric turbulence on aircraft performance are analyzed. The specific applications of infrared radiometer and Doppler lidar techniques are explained. Author

N74-19652# Advisory Group for Aerospace Research and Development, Paris (France)
DESIGN AGAINST FATIGUE
Dec. 1973 122 p refs Presented at the 37th Meeting of the Structures and Mater. Panel at the Hague, Netherlands, 7-12 Oct. 1973
(AGARD-CP-141) Avail: NTIS HC $9.25

Papers presented at the conference on designing aircraft against fatigue are reported. Fatigue analysis and tests for fighter aircraft are emphasized. For individual titles, see N74-19653 through N74-19660.

N74-19653 British Aircraft Corp., Preston (England)
SOME CONSIDERATIONS OF THE INFLUENCE OF FATIGUE IN THE DESIGN OF STRIKE AIRCRAFT
A. N. Rhodes *In* AGARD Design Against Fatigue Dec. 1973 17 p (For availability see N74-19652 11-02)

After summarizing some of the factors which characterize strike aircraft with regard to their fatigue design, the types of external loading to which it will be subjected in service are considered. A consideration is also given to some of the factors which influence the choice of materials, aircraft layout and design. Qualification of the finished product is discussed, as are some of the techniques in monitoring service usage. Problem areas are highlighted. Author

N74-19654 Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
FATIGUE DESIGN PRACTICE
K. Ahrensdorf *In* AGARD Design Against Fatigue Dec. 1973 18 p refs (For availability see N74-19652 11-02)

To define missions for fatigue analysis, mission breakdown and to estimate load spectra for combat or tactical aircraft a high degree of guesstimating is necessary. Available data as to operational mission and load spectra during aircraft development differ greatly, on the other hand these estimated data have a considerable influence on aircraft design. For this reason the aircraft design shall be in such a way that inspections in critical regions are possible and crack propagation is noncritical between inspection intervals. In addition, on all flying aircraft cg - acceleration measurements are necessary. Besides the results of full scale fatigue tests, to have available the complete information for individual life control of flying aircraft. Some aspects of the whole fatigue integrity program are discussed. Author

N74-19655 McDonnell Aircraft Co., St. Louis, Mo.
STRUCTURAL FATIGUE ANALYSIS AND TESTING FOR FIGHTER AIRCRAFT
L. F. Impellizzeri *In* AGARD Design Against Fatigue Dec. 1973 12 p refs (For availability see N74-19652 11-02)

The design of fatigue resistant structure includes a combination of fatigue testing analysis. A review of the structural design and development programs of the F-4 and F-15 aircraft highlights their spectrum fatigue testing and indicates that these tests are essential in providing a satisfactory level of structural integrity. An existing procedure is discussed which utilizes Neuber's rule and a cyclicly decaying residual stress function to continually track notch root stress-strain patterns. The technique was developed particularly to predict life for fatigue spectra with either a constant minimum stress or a constant mean stress. A modification of the technique is presented which simplifies its applicability for fatigue spectra with variable minimum and/or mean stresse. This also includes variable stress ratios. Life predictions using the modified technique are compared with spectrum test results on 7075-T6 aluminum and 6Al-4V titanium. An example is presented of crack initiation and crack growth caused by out-of-plane bending in a fighter airplane upper wing skin. The local structural detail is analyzed. Fatigue analysis in terms of crack propagation is performed based on the residual tension predicted by the elastic-plastic computer program as the crack extends. Calculated crack growth rates are compared with electron miscroscope photographs of the upper wing skin fracture surface showing striation spacings. Author

N74-19656 Grumman Aerospace Corp., Bethpage, N.Y.
FATIGUE AND FRACTURE CONSIDERATIONS FOR TACTICAL AIRCRAFT
I. G. Hedrick, L. B. Wehle, and P. D. Bell *In* AGARD Design Against Fatigue (date) 15 p refs (For availability see N74-19652 11-02)

A review of some of the practical aspects of designing against fatigue is presented. An outline is included of the latest fatigue analysis method used at Grumman and a discussion of some of the more interesting fatigue problems encountered in the evolution of several Grumman aircraft. Some new technological developments are discussed including the F-14 electron beam welded titanium wing carry-through box. The capabilities of some special Grumman inspection techniques to improve quality are reviewed. Author

N74-19657 Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany)

FULL SCALE FATIGUE REQUIREMENTS FOR RATIONAL FATIGUE LIFE PREDICTION

H. J. Zocher *In* AGARD Design Against Fatigue Dec. 1973 14 p refs (For availability see N74-19652 11-02)

After discussing a suitable fatigue life evaluation and certification procedure, some requirements are specified for full scale fatigue testing techniques which should be mandatory for future fatigue life substantiation. Test results obtained from two full scale fatigue tests utilizing different testing procedures are compared to service failures. The fatigue test which used the proposed improved testing technique with flight-by-flight loading sequence showed much better results which were in adequate correlation with service experience. Author

N74-19658 Royal Aircraft Establishment, Farnborough (England) Structures Dept

THE ROLE OF THE MAJOR FATIGUE TEST IN THE ACCEPTANCE, CERTIFICATION AND SAFE UTILISATION OF STRIKE AIRCRAFT

R. D. J. Maxwell *In* AGARD Design Against Fatigue Dec. 1973 8 p refs (For availability see N74-19652 11-02)

The role of the major fatigue test in acceptance, certification, and safe utilization of a strike aircraft is examined from the writing of the aircraft specification to the monitoring of life consumption in service. Attention is focussed on problems associated with defining the test load conditions and interpreting the results in terms of the monitoring system used, including the use of relevent flight load measurements. A summary of the problem areas and suggested minimum standards of fatigue testing, flight measurement and dissemination of the information are included. Author

N74-19659 National Aero- and Astronautical Research Inst., Amsterdam (Netherlands)

RE-ASSESSMENT OF FATIGUE PERFORMANCE OF FIGHTER AIRCRAFT

G. M. VanDijk *In* AGARD Design Against Fatigue Dec. 1974 19 p refs (For availability see N74-19652 11-02)

Fatigue monitoring results obtained by means of strain-gauge recordings are scrupulously compared to the reference full-scale fatigue test loading, finally yielding a relative fatigue severity index. The comparative analysis among other things highlights the importance of ground loads, counting methods and local plasticity at notch roots. A complex notch stress-strain history analysis is carried out to assess the notch root stress history and residual stresses. Finally, a simplified calculation procedure is suggested to account for notch root plasticity and residual stresses. This simplified analysis is a sufficiently accurate substitute of the complex notch stress-strain history analysis. Author

N74-19660 Societe Nationale Industrielle Aerospatiale, Paris (France)

DESIGNERS' NEED FOR GENERAL INFORMATION FROM ANALYSIS OF FATIGUE TEST RESULTS AND SERVICE BEHAVIOR

William Barrois *In* AGARD Design Against Fatigue Dec. 1973 13 p refs (For availability see N74-19652 11-02)

The requirements in fatigue assessment for designing aircraft structures are discussed in terms of interpretative computation, a priori subjective classification of fatigue strength, and prediction analysis. The analyses of fatigue behavior in tests and in service, and the standardization of test loading are discussed along with interpretation methods of fatigue test results, and the establishment of general data on fatigue strength. F.O.S.

N74-22634# Advisory Group for Aerospace Research and Development, Paris (France)

ABBREVIATED TEST LANGUAGE FOR AVIONICS SYSTEMS

D. A. Green Sep. 1972 61 p refs

(AGARD-LS-54) Avail: NTIS HC $6.25

The basic concepts of ATLAS and a selection of some of the more common verbs for constructing test procedures are presented. The overall organization is described of an ATLAS program, i.e., the division into preamble and procedural sections. Following this the general structure of an ATLAS statement is discussed to illustrate the general layout of a statement and its internal fields. The fields discussed are as follows: the fixed field which involves the flag, statement number and verb, and the variable field which includes the measured characteristic, noun, statement characteristic, and the evaluation and connection fields. It is shown that the organization of the variable field is determined by the verb used in the fixed field. Author

X74-73500 Advisory Group for Aerospace Research and Development, Paris (France)

PHYSICAL VULNERABILITY OF AIRCRAFT, VOLUME 1

F. D. Orazio Sep. 1972 48 p

(AGARD-AR-47-Vol-1) Classified Report

The overall utility of combat aircraft is influenced by the ability of the vehicle to absorb damage and still complete its mission and/or be repaired and returned to service rapidly. The report develops analysis techniques by which this characteristic of the aircraft may be assessed during the initial design phases and measured quantitatively as design features are established. The report also summarizes and evaluates the techniques which have been developed to reduce the physical vulnerability of aircraft.

X74-73501 Advisory Group for Aerospace Research and Development, Paris (France)

PHYSICAL VULNERABILITY OF AIRCRAFT, VOLUME 2

F. D. Orazio May 1973 234 p

(AGARD-AR-47-Vol-2)

Confidential Report

The overall utility of combat aircraft is influenced by the ability of the vehicle to absorb damage and still complete its mission and/or be repaired and returned to service rapidly. The report develops analysis techniques by which this characteristic of the aircraft may be assessed during the initial design phases and measured quantitatively as design features.

This study was conducted in response to a request from the North Atlantic Military Committee under the management of the Aerospace Applications Studies Committee.

X74-73502 Advisory Group for Aerospace Research and Development, Paris (France)

AIRCRAFT VULNERABILITY ANALYSIS, VOLUME 3

D. Kardels May 1973 70 p

(AGARD-AR-47-Vol-3) Secret Report

The report describes a detailed computer model for assessing the physical vulnerability of an aircraft to a variety of weapons and illustrates the use of the model by examples by evaluating three weapon types: 20, 30 and 35 mm shells against the RF-84E aircraft. The model provides sub-routines for describing the target and threat, evaluating the effect of the weapon on the components of the aircraft and assessing the impact of damage to component on the survivability of the aircraft. This volume constitutes an appendix to AR-47 Volume 2.

X74-73506 Advisory Group for Aerospace Research and Development, Paris (France)

LOW ALTITUDE FLIGHT CONTROL PROBLEMS

Feb. 1971 274 p Presented at Symp. of the Guidance and Control Panel of AGARD, Brussels, 1-3 Sep. 1970

(AGARD-CP-72)

Classified Report

The papers presented at the Guidance and Control Panel

sponsored Symposium on Low Altitude Flight Control Problems held at NATO Headquarters, Brussels, Belgium in September 1970. The papers address the problem of aircraft flight control conducted at high speeds at very low altitude and in all weather environments.

X74-73607 Advisory Group for Aerospace Research and Development, Paris (France).
MILITARY APPLICATIONS OF V/STOL AIRCRAFT. VOLUME 2
Jun 1973 76 p Presented at 41st Meeting of the Flight Mech Panel of Agard, Brussels, 23-25 Oct 1972
(AGARD-CP-126-Vol-2)

Classified Report

Five papers are contained in this Volume of the Proceedings. Two of the papers are related to the development and service operation of the "Harrier" V/STOL tactical aircraft. Another paper describes the history of the US/FRG V/STOL tactical fighter program. The last two papers are on the subject of future requirements for V/STOL aircraft.

03 AUXILIARY SYSTEMS

Includes fuel cells, energy conversion cells, and solar cells, auxiliary gas turbines, hydraulic, pneumatic and electrical systems, actuators, and inverters. For related information see also 09 Electronic Equipment, Nuclear Engineering, and 28 Propulsion Systems.

N73-19081# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT ON 39TH PROPULSION AND ENERGETICS PANEL MEETING ON ENERGETICS FOR AIRCRAFT AUXILIARY POWER SYSTEMS
R. H. Johnson (AFAPL), C. E. Oberly (AFAPL), and R. E. Quigley, Jr. (AFAPL) Nov. 1972 11 p refs Conf. held at Colorado Springs, 12-16 Jun. 1972
(AGARD-AR-50) Avail: NTIS HC $3.00

An evaluation of a conference to discuss current and future developments in aircraft electrical and auxiliary power systems is presented. Superconductivity phenomena as related to power generation are emphasized. The anticipated requirements imposed on weight, volume, and performance of auxiliary power systems which must operate in a high temperature environment are analyzed. Author

N73-19030+ Advisory Group for Aerospace Research and Development, Paris (France).
ENERGETICS FOR AIRCRAFT AUXILIARY POWER SYSTEMS
A. E. Fuhs, ed. (Naval Postgraduate School) Dec. 1972 314 p refs Mostly in ENGLISH, partly in FRENCH Proc. of 39th Meeting of the AGARD Propulsion and Energetics Panel held at Colorado Springs, 12-15 Jun. 1972
(AGARD-CP-104) Avail: NTIS HC $17.75

The proceedings of a conference on the use of superconductivity technology for electrical power generation in aircraft and missiles are presented. The advantages of superconductivity for power generation are described. The subjects discussed include (1) behavior of composite superconducting materials, (2) superconducting generators in aircraft, (3) cryogenic and inductive energy storage, (4) advanced airborne auxiliary power systems, (5) extraction of auxiliary power from air breathing propulsion systems, (6) electrical generation and distribution systems for supersonic aircraft, and (7) non radiating superconducting coils for energy storage. Line drawings, diagrams, charts, tables, and graphs are included to clarify the theoretical aspects. For individual titles, see N73-19031 through N73-19057.

N73-19031 Supertechnology Corp., Boston, Mass.
STABILITY OF A SUPERCONDUCTOR AS INFLUENCED BY THE SUBSTRATE
Ahmed Elbindari *In* AGARD Energetics for Aircraft Auxiliary Power Systems Dec. 1972 11 p refs (For availability see N73-19030 10-03)

The effects of substrates on the stability of a superconductor are discussed. Metal cladding in superconductive technology has resulted in improved reliability in design and utilizing of critical current densities as an almost operating condition. The voltage versus current characteristics of superconductors are illustrated. A numerical analysis of the performance of multi-filament superconductors is presented. Several conclusions concerning the electrical properties of superconductors and the effects of various parameters are presented. P.N.F.

N73-19032 Warwick Univ., Coventry (England). Dept. of Engineering.
THE BEHAVIOUR OF COMPOSITE SUPERCONDUCTING MATERIALS UNDER ac CONDITIONS
A. R. Eastham and R. G. Rhodes *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 11 p refs (For availability see N73-19030 10-03)

Alternating current loss mechanisms in superconductors are described with particular emphasis on the recently developed composite materials. Alternating transport current losses of a wide range of commercially available superconductors of the bare wire and multifilament composite types are presented. The behavior in coil and cable configurations is compared, and it is shown that when self-field effects predominate, little reduction in ac loss results from using multifilament composites as opposed to bare superconducting wire. When transverse field effects predominate, a substantial decrease in loss is possible with composite materials. The effect of transposing the individual filaments within a composite has been investigated, and it is shown that the ac loss can be reduced for a limited range of conditions. Material requirements for low loss conductors are discussed. Author

N73-19033 Max-Planck-Institut fuer Plasmaphysik, Garching (West Germany).
USE OF SUPERCONDUCTORS FOR PULSED EXPERIMENTS IN PLASMA PHYSICS
A. P. Martinelli *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 7 p refs (For availability see N73-19030 10-03)

Superconducting magnetics used in plasma experiments and as an essential component of possible future thermonuclear reactors are discussed. Many magnetic configurations for plasma experiments and for reactors as well consist of a stationary magnetic field produced by a superconducting magnet system on which a time dependent magnetic field is superposed. Examples are the sustained field configuration in theta pinch experiments, stellarators during switching on of the helical field, and tokamaks and stellarators during the field pulse used for ohmic heating of the plasma. The effect of pulsed magnetic fields on superconducting coils is studied in a number of non-stabilized single-core and multicore current carrying Nb-Ti superconductors in the form of short samples and small bifilar or inductive coils. Experimental results and calculation methods already reported are complemented and extended. The use and limitation of superconductors in pulsed magnetic configurations as field generating or field shielding coils are reported. Author

N73-19034 Union Carbide Corp., Tarrytown, N.Y. Linde Div.
HIGH FIELD PLASMA ARC-PLATED Nb3Sn SUPERCONDUCTING SOLENOIDS
R. Allan Reese *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 8 p refs (For availability see N73-19030 10-03)

Critical current data on plasma sprayed Nb_3Sn conductor for temperatures between 4.2 and 18 K and for magnetic fields up to 92 kilo Oersteds are reported. This data and stabilization data are used to study the effect on the mass of an airborne magnet system operating at temperatures above 4.2 K, and using aluminum vs copper stabilized conductor. The use of high conductivity aluminum is shown to substantially reduce the mass of the system. For the system considered, operation at elevated temperature is shown to result in a larger system mass since the increase in magnetic mass is much greater than the reduction in refrigerator mass. A comparison is made between refrigeration using a closed cycle refrigerator and using liquid helium carried on board. Author

N73-19035 Magnetic Corp. of America, Cambridge, Mass.
SUPERCONDUCTIVITY IN STEADY STATE AND PULSED APPLICATIONS FOR FLIGHT VEHICLES
E. J. Lucas, R. J. Thome, and Z. J. J. Stekly *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 9 p Sponsored in part by AFAPL (For availability see N73-19030 10-03)

The ability of the Type II superconductor to develop high magnetic fields while carrying high current densities naturally leads to applications that are related to power conversion and energy storage. Two major applications are presented: (1) MHD magnet systems and (2) pulsed inductive energy storage systems. The use of superconductors in winding for MHD magnets offer definite advantages in size and weight when compared with room temperature or cryogenic coils using normal conductor. This is primarily due to the higher attainable current density in

the windings and is graphically illustrated in plots which indicate the relative difference in total and component weights for a given field and field volume. As specific examples, weight and volume estimates are given for the magnet systems required for several power levels and a lightweight magnet system currently under development is described A comparison of inductive energy storage systems making use of normally resistive cryogenically cooled and superconducting coils is presented, as well as a comparison between inductive and capacitive energy storage elements. The current state-of-the-art in pulsed superconducting energy storage is discussed together with a description of recent results using a model coil. Author

N73-19036 Cranfield Inst. of Technology (England)
PROSPECTS FOR SUPERCONDUCTING GENERATORS IN AIRCRAFT
J. T. Hayden *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 7 p refs (For availability see N73-19030 10-03)

A review is given of the characteristics of present conventional alternators and aircraft electrical power systems. Preliminary considerations in the use of superconducting windings in 400 Hz alternators indicate that it is difficult to argue a case in favour of using superconducting machines for typical systems in use at present. Futher, there is probably a minimum size of 400 Hz generator for which it is practical to introduce superconducting windings below which there is no significant reduction in weight. If systems requiring powers of a few megawatts are considered, then the case for superconducting machines is much more promising providing that some cryogen (such as liquid nitrogen or liquid hydrogen) is already in the aircraft and available for cooling intermediate heat shields. Continued development in lightweight airborne helium refrigerators is also needed. Author

N73-19037 Laboratoire Central des Industries Electriques (France)
APPLICATION OF SUPERCONDUCTIVITY TO HOMOPOLAR MACHINERY USING LIQUID METALS
J. P. Chabrerie, G. Fournet, and A. Mailfert *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 4 p refs (For availability see N73-19030 10-03)

The concept of a homopolar machine with multiple discs and superconducting field winding, using liquid metals for the armature sliding electrical contacts is described. The possibilities of these kinds of machines used as motors or power supplies are analyzed. These machines operate with a low voltage and a high armature current, and their main features are an important power-to-weight ratio and a good efficiency. The main results of several studies are presented. These studies have led to the development of a 60 kW flooded rotor homopolar motor operating at low speed (600 r/min). After a short description of the model motor and a brief account of the main test results, the paper concludes with the choice of liquid metals, their applications to more powerful machines and the influence of the use of liquid metals on the machine morphology itself. Author

N73-19038 Ferranti-Packard Electric, Ltd., Toronto (Ontario)
LIGHTWEIGHT SUPERCONDUCTION MAGNET FOR AIRBORNE MHD GENERATORS
David L. Atherton *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1972 9 p refs Sponsored by USAF Aeropropulsion Lab and Canadian Defence Res Board (For availability see N73-19030 10-03)

A large lightweight saddle-coil superconducting dipole magnet for airborne MHD generators is described. The magnet has a room temperature bore of 27.7 cm, a winding bore of 33 cm, a design field of 4.5 tesla, a magnetic length of 105 cm and a mass of 450 kilograms. The dipole field is generated by pancake winding whose cross sectional outline approximates overlapping circles. Lightweight necessitates high current density, 2,100a in a 2 mm square conductor containing 200 twisted Nb-Ti filaments in a copper matrix. The Lorenz repulsive force between opposite sides of the magnet is 3850 kilogauss per centimeter of coil length. There are also large compressive forces on the former and repulsive forces between the ends. The mechanical structure therefore uses a highly stressed lightweight structure of filament wound epoxy glass composite. The dewar uses superinsulation and vapour cooled radiation shields. Vibration and shock analysis and pressure vessel design criteria determine the minimum mass dewar design. Author

N73-19039 Magnetic Corp. of America, Cambridge, Mass.
SUPERCONDUCTING GENERATORS
Z. J. J. Stekly (Tex. Univ. Austin) and H. H. Woodson *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 14 p refs Sponsored by United Aircraft Corp. and AFAPL (For availability see N73-19030 10-03)

The development of alternating current machines using superconducting windings is discussed. The design philosophy and details of specific experimental generators are examined. The characteristics of the field winding based on electromagnetic, electromechanical, structural, and cryogenic effects are described. The design criteria resulting from the interaction of these parameters are developed. The results of a study of size and weight as a function of power level and frequency are presented. Author

N73-19040 Westinghouse Electric Corp., Pittsburgh, Pa. Research Labs
SUPERCONDUCTING ELECTRICAL MACHINERY
C. J. Mole, J. H. Parker, Jr., and L. R. Lowry *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 15 p refs (For availability see N73-19030 10-03) (Contract F33615-71-C-1591)

The more important types of superconducting machines, the features and problems inherent in such machines, and the more promising applications are reviewed. Both ac and dc superconducting machines are discussed with particular emphasis on the application of ac machines for aircraft use. Recent and current developments in the field are reported. Author

N73-19041 Commissariat a l'Energie Atomique, Saclay (France)
ENERGY STORAGE AND DISCHARGE BY SUPERCONDUCTORS [STOCKAGE ET DECHARGE D'ENERGIE AU MOYEN DU SUPRACONDUCTEURS]
P. Genevey, G. Prost, J. Sole, and B. Girard *In* AGARD Energetics for Aircraft Auxiliary Power Systems Jan 1971 8 p refs In FRENCH (For availability see N73-19030 10-03)

After an examination of the principles of electric energy storage and discharge, a detailed analysis was made of load operations, trapping, and different problems raised about storage and discharge. The effects of load operation on the utilization of high flux pumping and the discharge that is released by means of rapid transition superconductor commutators are also analyzed. Experimental results are included. Transl. by E.H.W.

N73-19042 Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. fuer Energiewandlung und Elektrische Antriebe
RESEARCH ON CRYOGENICS AND INDUCTIVE ENERGY STORAGE AT THE DFVLR
C. Carpetis *In* AGARD Energetics for Aircraft Auxiliary Power systems Feb 1972 7 p refs (For availability see N73-19030 10-03)

The use of superconducting coils for energy storage is discussed. The objective was to find the optimizing parameters and to define the problems which involve the technical use of inductive energy storage. It was determined that (1) the geometry of the coils is essential for optimal performance, (2) high critical current density rather than high critical field is important for optimal devices, and (3) the mass of the superconductor may be small as compared with the needed structural mass. The development of cryogenically cooled devices, particularly in the presence of time varying fields, is reported. Author

N73-19043 Centre d'Etudes et Recherches de la Compagnie Electro-Mecanique, Le Bourget (France). Groupe d'Etudes Cryotechniques
NONRADIATING SUPERCONDUCTING COILS FOR ENERGY STORAGE

M. Gayte, B. Girard, and A. Malardain *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 6 p refs (For availability see N73-19030 10-03)

The characteristics of superconducting coils as energy storage elements are investigated together with the main problems affecting their design: electromagnetic forces, energy radiation and discharge losses. An ellipsoid coil set into a shielding coil is then described; its outer field is zero and its shape suitable to withstand the electromagnetic forces. The relation stored energy/superconductor volume is particularly high. An experimental coil located in a stainless steel cryostat was built allowing for the control of the calculation method and the study of the effect of the differences between the real and the theoretical shapes. Author

N73-19044 Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany)

ADVANCED POWER GENERATION IN MISSILES

O. Stumpf, H. Loeser, and H. Sharf *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1972 13 p refs (For availability see N73-19030 10-03)

Power generating systems and their application in modern missiles for the production of hydraulic and/or electric energy are discussed. A system weight analysis for 5 different systems is described which shows the application regimes in terms of output power and mission time. Details of recently developed components are given. Author

N73-19045 AiResearch Mfg Co., Phoenix, Ariz.

ADVANCED AIRBORNE AUXILIARY POWER SYSTEM

D. F. Swenski, L. W. Norman, and A. D. Meshew *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1972 12 p ref (For availability see N73-19030 10-03)

An advanced auxiliary power unit (APU) was combined with an accessory drive system to form an auxiliary power system (APS). This APS was used as an exploratory development test bed for the development of advanced technology components. The APS included a 300 equivalent shaft horsepower APU configured to furnish bleed air from a split flow impeller and shaft power at 130 F, sea level ambient conditions. The APS was designed to provide standby power separate from the accessories and engine drive train, checkout engine starting, and emergency power through a high-speed torque converter. The design of the APS was intended to form a test bed representing the optimum configuration as determined from a systems analysis, with a high degree of flexibility such that the components thus developed may be applicable to many other future APS designs. Author

N73-19046 Kloeckner-Humboldt-Deutz A.G., Oberursel (West Germany)

AUXILIARY POWER UNITS FOR SECONDARY POWER SYSTEMS

Erwin Schnell *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1972 9 p (For availability see N73-19030 10-03)

The design principles for the auxiliary power units of a secondary power system for use in aircraft are presented. The single shaft turbine is compared with the free power turbine for auxiliary power unit applications. The equipments operated by the auxiliary power unit is discussed and the components of the electrical system are analyzed. Author

N73-19047 Messerschmitt-Boelkow G.m.b.H., Munich (West Germany)

PULSE JET ENGINE AS A SOURCE OF ENERGY FOR AUXILIARY POWER UNITS: PULSE GAS TURBINE WITHOUT COMPRESSOR

W. K. Eick *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1972 12 p (For availability see N73-19030 10-03)

A short survey of the elements of an intermittent pulse jet engine, open on both sides, which has been tested up to the supersonic speed is presented. The results show that such an airbreathing unit can also be used as a gas generator acting upon a turbine rotor for taking off mechanical power. The basic design of the engine consists of a thin-walled welded steel construction of conical and cylindrical shape, without any mechanically moved, rotating or oscillating parts. A spark plug for intermittent external ignition for starting and a fuel control device belong to the basic version of the engine. The turbine is driven by the hot gases which are intermittently expelled from the combustion chamber. The power unit can also be selectively used after diversion as a propulsion engine. The low costs of manufacturing and maintenance for such engines are pointed out. The influence of the most important parameters is explained. The auto-ignition, based on the principle of residual gas including shock wave rate, is an important functional feature of the pulse jet engine. Author

N73-19048 Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio. Auxiliary Power Units

DUAL MODE AUXILIARY POWER UNIT FOR HIGH MACH AIRCRAFT

Buryl L. McFadden, Jr and Richard E. Quigley, Jr *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1973 9 p refs (For availability see N73-19030 10-03)

Advanced high performance aircraft are projected to employ ramjet, turboramjet, and rocketramjet engines. Since ramjet engines do not incorporate rotating members, they cannot provide shaft horsepower for aircraft accessories and flight control systems. Therefore, some form of auxiliary power source will be required to furnish the hydraulic, electric, pneumatic and shaft power for the various aircraft systems during flight, thus the auxiliary power source must become the prime and only source of shaft power during high speed flight. Various power source configurations to accomplish this are reviewed with emphasis on the potential of a single dual mode power source sized to provide all flight vehicle power throughout the entire operating regime of the aircraft including ground standby. Since they are totally independent, such a configuration will permit design optimization of both the main propulsion engines and the power system. Author

N73-19049 British Aircraft Corp., Preston (England). Military Aircraft Div.

INTEGRATION OF AUXILIARY POWER SYSTEMS WITH THE MULTI-SPOOL ENGINE

Len W. Milsom *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1973 8 p (For availability see N73-19030 10-03)

As engine technology advances certain engine/airframe interface problems arise with aircraft auxiliary power systems. Using a modern strike aircraft as the principal example, this paper examines the difficulties in meeting the airframe mechanical power requirements of generating excessive wasted energy in air bleed systems and of dissipating the waste heat from engine and airframe accessories. Much closer collaboration between airframe and engine contractors at the early stage of an aircraft project, in order to develop a combined approach to the solution of these problems, is recommended. Author

N73-19050 Motoren-Und Turbinen-Union Muenchen G.m.b.H. (West Germany)

EXTRACTION OF AUXILIARY POWER FROM AIRBREATHING PROPULSION SYSTEMS

Klaus Bauerfeind *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb. 1973 13 p (For availability see N73-19030 10-03)

The characteristics of gas turbine engines for use as auxiliary power sources are discussed. The direct supply of mechanical power and pressurized air from turbines is examined. The most important criteria for the auxiliary power sources are identified as: (1) maximum possible power delivery points, (2) compressor surge margins, (3) effect on handling characteristics of aircraft, and (4) effect on windmilling characteristics of turbine engine. Data are presented in the form of graphs to show interrelationships of turbine engine parameters. Author

N73-19051 Politecnico di Milano (Italy). Ist. di Macchine

A METHOD FOR PRELIMINARY ANALYSIS OF MHD GENERATOR PERFORMANCE

C. Casci, A. Coghe, and U. Ghezzi *In* AGARD Energetics for

Aircraft Auxiliary Power Systems Feb. 1972 12 p refs (For availability see N73-19030 10-03)

The characteristics of magnetohydrodynamic generators for aircraft and spacecraft applications are discussed. A method for analyzing the parameters of a magnetohydrodynamic generator is developed. The analysis is obtained by fixing the total enthalpic difference between the inlet and outlet sections of the duct and by examining the various possibilities through which such a condition may be achieved. Thermodynamic and electromagnetic quantities are studied in relation to the velocity difference between the inlet and outlet sections of the duct and by some other parameters, such as expansion ratio and form factor of the duct Author

N73-19062 Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio

DEVELOPMENTS IN AIRCRAFT ELECTRICAL POWER SYSTEMS

Robert H Johnson *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1972 7 p refs (For availability see N73-19030 10-03)

A summary of Air Force research and development programs in aircraft electrical power systems and components is presented. The planning process used to validate research programs is discussed with emphasis on the resultant motivation to develop specific classes of technology. Specific programs discussed are (1) solid state power controllers, (2) gate controlled switch technology, (3) solid state electric power simulator tests, and (4) high temperature electrical generators, wire, and connectors Author

N73-19063 Vought Aeronautics, Dallas, Tex

APPLICATION OF SOLID STATE SWITCHING AND MULTIPLEXING TO AIRCRAFT ELECTRICAL SYSTEMS

Clyde W Jones (AFAPL) and Jim Courter *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1973 9 p (For availability see N73-19030 10-03)

The application of solid state switching, multiplexing, and electrically programmable logic to aircraft electrical systems is discussed. The effects of the use of solid state switching technology on electrical system weight, reliability, electromagnetic interference, and quality of power delivered to loads are analyzed. A summary of problems encountered with proposed solutions, during a program in which a completely solid state electrical system for an A-7 aircraft was evaluated, is included. Areas of improvement and expanded capability are also enumerated Author

N73-19064 Royal Aircraft Establishment, Farnborough (England) Engineering Physics Dept

ELECTRICAL GENERATION AND DISTRIBUTION SYSTEMS FOR FUTURE SUPERSONIC AIRCRAFT

A Bainbridge *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1972 7 p refs (For availability see N73-19030 10-03)

The size of the total electrical load and the temperature range over which some components will have to operate make it necessary to study new generation and distribution techniques to satisfy the demands of future aircraft flying in the supersonic or hypersonic range. This paper is restricted to supersonic aircraft and discusses recent proposals for improved distribution systems incorporating solid state switching and using remote control of protective devices through a multiplexed system. The scope for high temperature wiring is briefly discussed and a few recent developments in generators and power cables are described, since the generating system is particularly vulnerable to extreme environmental conditions Author

N73-19065 Societe d'Applications des Machines Motrices S.A., Issy-les-Moulineaux (France)

ADIABATIC COMPRESSION OF OILS EASILY MEASURED FROM PUMP AND MOTOR YIELD [COMPRESSION ADIABATIQUE DES HUILES MESURES AISEES DES RENDEMENTS DES POMPES ET MOTEURS]

Jacques Faisandier *In* AGARD Energetics for Aircraft Auxiliary Power Systems Dec 1972 8 p In FRENCH (For availability see N73-19030 10-03)

Formulas are reported for calculating the influence of adiabatic oil compression on transmission power of hydraulic systems. Calculations were also made of pump and motor destruction, and the valve of thermal destruction due to oil overheating in the pumps Transl. by E.H.W

N73-19066 British Aircraft Corp., Weybridge (England).

PNEUMATICS IN SUPERSONIC ENERGETICS

John Wotton *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1973 15 p (For availability see N73-19030 10-03)

A pneumatics orientated integrated system concept developed for subsonic civil aircraft is examined in its relation to supersonic operation. The principle of waste heat extraction for the generation of auxiliary power supplies is found to be even more viable due to greater cabin pressure differential during cruise, and the level of engine compressor tapping required in consequence. The economics of engine bleed are examined in the light of virtually free electrical generation in the method employed. Pneumatic power conversion is shown to be at least competitive with hydraulic and other equivalents, and the requirements of power flying controls to be satisfactorily met Author

N73-19067 Pisa Univ (Italy) Facolta di Ingegneria.

THEORETICAL MODELS FOR PLASMA MOTION IN PULSED COAXIAL HYDROMAGNETIC GUNS

M Andrenucci, M Caprili, and R Lazzeretti *In* AGARD Energetics for Aircraft Auxiliary Power Systems Feb 1972 17 p refs (For availability see N73-19030 10-03)

A theoretical study of the performance of pulsed coaxial plasma guns is described. The electromechanical equations are derived for a snowplow model allowing for a variable initial mass-loading distribution. Computer results for two families of distributions are presented and analyzed. The values of the system parameters that yield highest value of kinetic efficiency are determined for widely varied conditions. A modified model allowing for the actual variation of the magnetic pressure with the radius is formulated and preliminary results for this model are discussed. Finally an account is given of the numerical methods employed in solving the sets of coupled differential equations describing the system in the assumed models Author

04 BIOSCIENCES

Includes aerospace medicine, exobiology, radiation effects on biological systems; physiological and psychological factors For related information see also 05 Biotechnology

N71-20076# Advisory Group fo Aerospace Research and Development, Paris (France)

GLOSSARY OF AEROSPACE MEDICAL TERMS. ENGLISH-FRENCH AND FRENCH-ENGLISH [GLOSSAIRE DES TERMES UTILISES EN MEDECINE AEROSPATIALE. ANGLAIS-FRANCAIS ET FRANCAIS-ANGLAIS]

D I Fryer, ed Jan 1971 54 p ref In ENGLISH and FRENCH Revised

(AGARD-AG-153-71, AGARDOGRAPH-153) Avail NTIS

A glossary of new terms is presented by the AGARD Aerospace Medical Panel The terms are limited to those having a specific meaning in Aerospace Medicine or peculiar to that field of study

Author

N71-20351# Advisory Group for Aerospace Research and Development, Paris (France)

ADAPTATION AND ACCLIMATISATION IN AEROSPACE MEDICINE

H J Grunhofer ed Mar 1971 207 p refs Presented at 27th Aerospace Med Panel Meeting Garmish Partenkirchen West Germany, 14 - 18 Sep 1970

(AGARD CP-82-71) Avail NTIS

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17 METABOLIC IMBALANCES AND BODY HYPOHYDRATION DURING FOOD DEPRIVATION (10 DAYS) C F Consolazio H L Johnson, and H J Krzywicki (Army Medical Research and Nutrition Lab) 8 p refs (See N71 20368 09-04)

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19 EFFECT OF ACUTE AND CHRONIC EXPOSURE TO 21 MM HG AMBIENT P SUB CO2 ON EXERCISE RESPONSE OF NORMAL MAN R D Sinclair J M Clark and B E Welch (School of Aerospace Medicine) 9 p refs (See N71 20370 09-04)

20 VOLITIONAL CONTROL OF VISUAL ACCOMMODATION R J Randle (NASA Ames Research Center Moffett Field Calif) 13 p refs (See N71 20371 09 04)

N71-20352# Office of Naval Research, Arlington, Va

ACCOUSTIC FATIGUE OF HUMANS EXPOSED TO NOISE

Gilbert C Tolhurst In AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 8 p refs (See N71 20351 09-04) Avail NTIS

Since human fatigue is not truly a precise phase by borrowing an analogy from the material sciences an attempt has been made to outline both physiologically and psychologically the limits and ranges of the response to acoustic stimuli termed elasticity, deformation and destruction The precision is no better or no worse than the same terms applied to metal fatigue Present damage-risk criteria if strictly applied by industry the military or by social services organizations should materially reduce the incidence of noise induced hearing losses to approximately 85 to 95 percent of a population Considerable amounts of data are needed to allow any particular individual's susceptibility to be predicted with precision While considerable research effort has yielded ever increasingly elegant methods to quantify potentially hazardous noise environments as well as communications interfering ones the consequences of prolonged noise exposure need extensive experimental validation

Author

N71-20353# Army Medical Research Lab Fort Knox Ky Experimental Psychology Div

GROWTH AND RECOVERY OF TEMPORARY THRESHOLD SHIFTS FOLLOWING EXTENDED EXPOSURE TO HIGH LEVEL, CONTINUOUS NOISE

James D Mosko and John L Fletcher *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 7 p refs (See N71-20351 09-04)
Avail NTIS

Requirements of long term operations for both air and ground military personnel have increased in recent years, and the probability of having such personnel exposed to hazardous noise levels and durations has increased. Research was undertaken to investigate the effects of long term exposure on the auditory thresholds for discrete tonal signals and the recovery from any temporary threshold shift. Evidence indicates a gradual growth in temporary threshold shift (TTS) over 12 16 hours of exposure with an asymptotic TTS configuration extending through 48 hours of exposure. Full recovery is attained in approximately 23 24 hours after cessation of exposure. The results of this research could lead to reconsideration of the damage risk criteria for noise exposure and to the design of protective devices. Author

N71-20354# Randomline Inc, Willow Grove, Pa
CARDIAC AND NEURAL EFFECTS OF RADAR WAVELENGTHS
Allan H Frey *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 6 p (See N71-20351 09-04)
Avail NTIS

Results of experimentation on the cardiac effects of UHF energy are reviewed. A series of three experiments were conducted, the first two experiments used isolated frog hearts and the third used intact frogs. The UHF energy was synchronized with events in the ECG in an attempt to drive the heart. Synchronization with the R wave had significant effects. Author

N71-20355# Matrix Corp, Alexandria Va
FLIGHT CREW ADAPTABILITY TO THE HELICOPTER VIBRATION ENVIRONMENT
J W Danaher *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 5 p refs Sponsored by ONR (See N71-20351 09-04)
Avail NTIS

Interpretations of research literature concerning the effects of vibration on man are presented. Described are some effects of vibration on the performance of certain flight crew tasks required by emerging helicopter missions. Specifically the implications for long duration, search and rescue and assault support missions are discussed. Tasks associated with the operation of various human sensory systems, digital input devices and helmet-mounted and other displays are also analyzed. Areas requiring further research are defined and engineering approaches to the solution of the helicopter vibration problem are outlined. Author

N71-20356*# National Aeronautics and Space Administration Washington, D C
VIBRATION IN V/STOL AIRCRAFT
Walton L Jones *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 10 p refs (See N71-20351 09-04)
(NASA-TM-X-66956) Avail NTIS CSCL 06S

The ride comfort program being conducted at Langley Research Center is described. This program assesses those characteristics of V/STOL vibration which influence human comfort. Vehicle measurements correlated with the results from simulation experiments will yield the recommended ride comfort criteria. Also described is (1) a planned study of an active vibration isolation system designed to eliminate approximately 90% of the vibration at the primary frequency of 18 cycles per second and (2) a ride comfort simulator having three degrees of freedom, a payload capacity of 5,000 pounds and vertical and lateral direction having peak to peak double amplitude of six inches with plus and minus 0.5 g. A L

N71-20357# Royal Air Force Inst of Aviation Medicine Farnborough (England)
EFFECT OF POSTURE ON TOLERANCE TO POSITIVE (Gz) ACCELERATION
R J Crossley and D H Glaister *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 8 p refs (See N71-20351 09-04)
Avail NTIS

The effect of varying the posture of eight subjects on their relaxed greyout thresholds has been studied. Six angles of the seat back between 70 deg to the horizontal and 15 deg and rates of onset of acceleration of 1.0 g/sec and 0.1 g/sec were used. The g thresholds of all subjects with both rates of onset increased as the back angle decreased and were directly proportional to the reciprocal of the vertical distance between the eye and the haemodynamic indifference point. The degree of neck flexion was observed to have little effect on the thresholds at any one angle. Four subjects also wore an anti g suit for further threshold determinations with seat back angles of 70 deg, 30 deg and 15 deg. The increase in thresholds produced by the anti g suit was the same for each angle. Comparison of the thresholds observed with the two rates of onset show that the 0.1 g/sec rate leads to higher thresholds than the 1.0 g/sec rate. These studies indicate that a near supine posture combined with an anti g suit can provide relaxed g thresholds in the region of 6 to 8 g while permitting adequate forward vision. Such a posture would have the added advantage of exposing the aircrew to - g sub x acceleration during ejection. Author

N71-20358*# Mayo Clinic, Rochester, Minn Graduate School of Medicine
EFFECTS OF POSITIVE Gy ACCELERATION ON BLOOD OXYGEN SATURATION AND PLEURAL PRESSURE RELATIONSHIPS IN DOGS BREATHING FIRST AIR, THEN LIQUID FLUOROCARBON IN A WHOLE BODY WATER IMMERSION RESPIRATOR
D J Sass, E L Ritman, P E Caskey, J Greenleaf, N Banchero et al *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 15 p refs Sponsored in part by Navy (See N71-20351 09-04)
(Grant NGR 24 003 001, Contract F41609-69-C-0058, Grant NIH HE 3532)
(NASA-CR-117199) Avail NTIS CSCL 06S

A total body water immersion mechanical respiration, body support assembly has been used with dogs on the human centrifuge to compare effects of + 1 Gy and + 6 Gy acceleration on cardiovascular and respiratory function in dogs under three conditions (1) normal respiration in air, (2) totally immersed in a saline filled respirator chamber providing control of respiratory rate, tidal and residual volumes when breathing air or oxygen, and (3) when respired in the same manner with oxygenated liquid fluorocarbon. The results indicate that (1) arterial hypoxemia due to dependent pulmonary arteriovenous shunting caused by acceleration is not minimized by water immersion alone, (2) dogs can be respired with liquid fluorocarbon for four hours or longer without clinical signs of respiratory distress, (3) liquid respiration prevented dependent pulmonary arteriovenous shunting at + 6 Gy, (4) vertical gradients in pleural pressure gradients were approximately 0.7 cm H2O/cm vertical distance between pleural catheter tips in air breathing dogs in contrast to greater than 1.0 cm H2O cm vertical distance in liquid breathing experiments and (5) liquid breathing prevented inertial displacements of the heart and other mediastinal structures to dependent sites in the thorax and roentgenographically evident pulmonary atelectasis in dependent regions. Author

N71-20359# Aerospace Medical Research Labs, Wright-Patterson AFB Ohio
AGE AND EXERCISE AS FACTORS INFLUENCING OSTEOPOROSIS, BONE STRENGTH, AND ACCELERATION TOLERANCE
I E Kazarian and H E Von Gierke *In* AGARD Adaptation and

Acclimatisation in Aerospace Med Mar 1971 21 p refs (See N71-20351 09-04)
(AMRL-TR-70-74) Avail NTIS

Spinal injury associated with escape from high performance aircraft has tended to occur more frequently in the aged than the younger aircrewman population Although an age influence for this trauma has not been clearly demonstrated, it must be hypothesized Osteoporosis is part of the normal aging process and accompanies most diseases affecting man Disuse osteoporosis appears to be an exaggeration of the normal aging process Mechanical stress, such as that produced by exercise and physical activity, is necessary for the retention of skeletal mass and may be a specific influence in controlling the adverse effects of osteoporosis To produce a partial answer to the questions raised and their potential operational significance, 24 adult rhesus monkeys were subjected to 60 days of physical inactivity The results show a decrease in spinal impact tolerance in terms of vertebral body fracture when experimentally produced osteoporotic primates were exposed to whole body longitudinal spinal impact Histopathological examination at points of tendinous and ligamentous attachment show increased bone modeling activity Author

N71-20360# Army Aeromedical Research Lab Fort Rucker Ala
PROBLEMS OF ADAPTATION TO LONG RANGE LARGE SCALE AERIAL TROOP DEPLOYMENT
Stanley C Knapp *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 14 p refs (See N71-20351 09-04)
Avail NTIS

Stresses and adaptation problems demonstrated during large scale, long range rapid reaction time aerial troop deployments are described NATO Exercise REFORGER 1 and other recent large scale aerial troop deployments are discussed Author

N71-20361# Texas Univ Galveston Dept of Neurology and Psychiatry
IMPULSIVENESS AND ANXIETY RELATED TO PERCEPTUAL MOTOR PERFORMANCE
Ernest S Barratt and Gilbert Tolhurst (ONR Arlington, Va) *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 5 p refs (See N71-20351 09-04)
(Contract N00014-68-A-0105-0002)
Avail NTIS

Anxiety and impulsiveness have been studied within a conceptual framework that recognizes four classes of variables (1) everyday life experiences, (2) psychometric tests and psychometric interviews, (3) laboratory behavioral measures and (4) psychophysiological measures The overall goal was to describe anxiety and impulsiveness across all four classes of variables for both stress and nonstress conditions Examples of the relationship of the interaction of impulsiveness and anxiety to perceptual motor performance are presented within the context of a brief discussion of the overall research program Author

N71-20362# Aerospace Medical Research Lab Wright-Patterson AFB, Ohio
EFFECTS ON HUMAN PERFORMANCE OF COMBINED ENVIRONMENTAL STRESSES
Walter F Grether *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 10 p refs (See N71-20351 09-04)
Avail NTIS

Research studies of environmental effects normally expose subjects to only one stress at a time while in operational flying there are usually several stresses acting simultaneously The possibility exists that effects of such combined stresses may be greater than would be predicted from single stress studies There have been relatively few laboratory studies of human performance in which the subjects have been exposed to such combined stresses A critical review is presented of these past studies from the particular viewpoint of whether performance decrements from combined stresses are more severe than would be predicted from single stress studies Although the number of past studies is not sufficient to present a consistent or conclusive picture, they do suggest that combinations of environmental stresses do not present a special hazard in flying that could not be anticipated from results of single stress studies Author

N71-20363# Royal Air Force Inst of Aviation Medicine, Farnborough (England)
THE NOVEL TASK AS A MEASURE OF PERFORMANCE UNDER ENVIRONMENTAL STRESS
M F Allnutt *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 4 p refs (See N71-20351 09-04)
Avail NTIS

Experiments were conducted to determine human performance on a complex reasoning test under the stresses of temperature and altitude In the analysis of the data special attention was given to those situations in which the subjects first acquaintance with the task was under the stress condition The experimental work along with a discussion of the advantages and disadvantages of using a novel task to assess performance under environmental stress is briefly discussed Author

N71-20364# Centre d'Enseignement et de Recherches de Medecine Aeronautique, Paris (France) Lab Central de Biologie Aeronautique
IS LABORATORY EXPERIMENTATION USEFUL FOR STUDYING HUMAN ADAPTATION TO UNINHABITABLE SENSORY ENVIRONMENTS? [L'EXPERIMENTATION EN LABORATOIRE EST-ELLE PERTINENTE POUR ETUDIER L'ADAPTATION DE L'HOMME AUX ENVIRONMENT SENSORIELS INHABITUELS]
Roger Angiboust *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 7 p In FRENCH, ENGLISH summary (See N71-20351 09-04)
Avail NTIS

Two experiments were conducted to study the adaptation of voluntary subjects to a degraded sensorial environment These experiments showed that (1) The behavioral and physiological response to an unusual environment depends on the subjects' level of education and personal interest in the test (2) Adaptation to an unusual environment can be modified by giving to the tested subjects psychoaneleptics which induce behavioral manifestations of inadaptation in subjects who had been so far free from them In light of these experiments, it appears that for the subject, the significant stimulus is not the physical one or the arrangement of physical stimuli which excites his senses but the meaning which he gives to the overall experiment situation, and the way he feels it The importance of the decrement of physical stimuli does not affect the behavioral manifestations of inadaptation The same physical environment can be felt as a neutral, indifferent stimulus or, on the contrary, as an aggressive, nociceptive stimulus Author

N71-20365# Italian Air Force Psycho Phsiological Inst Naples
THE PSYCHOTHERAPEUTIC METHOD IN AVIATION PSYCHIATRY IN THE TREATMENT OF SOME SYNDROMES OF A REACTIVE CHARACTER
L Longo *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 10 p refs (See N71-20351 09-04)
Avail NTIS

The usefulness in aviation psychiatry of psychotherapeutic treatment of some syndromes of a reactive character is shown through the description of 7 cases synthetically reported in their most indicative constitutive elements and in the psychodynamic modality of the relative psychotherapeutic treatment Stress was laid on the advantages that accrue from the fact of being able to carry out the therapy in the environment itself and on the favorable implications that can derive from it both on the strictly clinical plane and on the more specific one of maintaining and regaining flight fitness Author

N71-20366# Italian Air Force Aerospace Medical Center, Rome (Italy)

EXPERIMENTAL RESEARCH ON HEAT BALANCE OF ATHLETES OF VARIOUS SPECIALTIES, DURING MUSCULAR EXERCISE IN DIFFERENT THERMAL ENVIRONMENTS

Paolo Rota and Antonio Todaro (Accident Prevent Natl Agency Res Center) *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 8 p refs (See N71-20351 09-04)
Avail NTIS

Athletes trained to different muscular exercises (long distance runners and sprinters) carried out work tests under conditions of thermal neutrality and in hot environments. During the tests physiological parameters were recorded (central and skin temperatures, sweat loss, oxygen intake, work load, etc.) in order to calculate heat balance. Based on accumulated data, the behavior of thermal regulation, in respect to the different athletic specialties of the subjects tested, is discussed. Author

N71-20367# Army Medical Research and Nutrition Lab., Denver Colo. Bioenergetics Div.

ENERGY METABOLISM DURING EXPOSURE TO EXTREME ENVIRONMENTS

C. F. Consolazio, H. L. Johnson, and H. J. Krywicki *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 11 p refs (See N71-20351 09-04)
Avail NTIS

The energy requirements in a cold environment are practically unchanged as compared to a temperate environment, except for the 2 to 5% increase due to the wearing of the heavy clothes and footgear, providing that the individual is adequately clothed. However the daily energy requirements for men living and working in a hot environment are increased. This is related to the increased requirement of the circulation in heat transport, the increased action of the sweat glands, increased caloric loss due to sweat vaporization and to the increase in body temperature. Balance studies including losses of nutrient in sweat indicate that these excretions are appreciable under conditions of profuse sweating. In the past, with the exception of sodium, very few investigators have recognized the fact that the mineral losses in sweat could be appreciable. The total mineral loss should include the mineral loss in sweat. This in turn would help in estimating more realistically the minimal daily allowances of minerals. Author

N71-20368# Army Medical Research and Nutrition Lab., Denver Colo. Bioenergetics Div.

METABOLIC IMBALANCES AND BODY HYPOHYDRATION DURING FOOD DEPRIVATION (10 DAYS)

C. F. Consolazio, H. L. Johnson, and H. J. Krzywicki *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 8 p refs (See N71-20351 09-04)
Avail NTIS

During studies of 6 men who fasted completely for 10 days, significant metabolic stresses developed which could eventually lead to serious abnormalities. These observations included great body hypohydration resulting in large body weight losses, large nitrogen and mineral losses, and a marked ketosis. These findings are not unusual since both the body fat and protein stores must be utilized as energy sources. The maintenance of normal blood carbohydrate levels require a known quantity of protein breakdown. As a result, it was suggested that low, anti-ketogenic diets and adequate mineral supplementation could prevent the marked ketosis, minimize protein catabolism, maintain fluid balance, and decrease the electrolyte excretion. EKG's and EEG's were normal in both groups during the entire study. It appears that restricted diets containing less than 500 calories/day are inadequate for short term performance. Although they spared water, the protein catabolism was still a major problem. Author

N71-20369# Dunlap and Associates, Inc., Santa Monica, Calif.

THE INFLUENCE OF ENVIRONMENTAL FACTORS IN AIRCRAFT CARRIER LANDINGS AND ACCIDENTS

Clyde A. Brictson *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 7 p refs (See N71-20351 09-04)
Avail NTIS

An analysis of carrier landing accidents during a five year period (1965 - 1969) showed that environmental causal factors contributed to 27% of all jet landing accidents. Pitching deck was the most frequently cited environmental causal factor and was cited in 15% of the landing accidents. The F4 aircraft had the highest percentage of environment related mishaps (36%), half of which were pitching deck accidents (18%). Furthermore, pitching deck conditions were found to be related to two accident types, hard landings and undershoots, which accounted for 93% of all landing accidents. Pilot/aircraft height tracking responses under different levels of deck pitch were analyzed and results indicate that deck motion in excess of four feet may result in a 180 deg phase relation between deck pitch and pilot height tracking for certain aircraft. Synchronized records of deck motion and pilot aircraft height tracking during final approach to night carrier landing deck chasing phenomenon and provide graphic evidence of the consequences of 180 deg phase lags, especially for high accident risk aircraft. Author

N71-20370# School of Aerospace Medicine, Brooks AFB, Tex. Environmental Systems Div.

EFFECT OF ACUTE AND CHRONIC EXPOSURE TO 21 mm Hg AMBIENT P SUB CO2 ON EXERCISE RESPONSE OF NORMAL MAN

R. D. Sinclair, J. M. Clark and B. E. Welch *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 9 p refs (See N71-20351 09-04)
Avail NTIS

Physiologic responses to the interacting stresses of exercise and hypercapnia were studied in 4 young male subjects who were well trained and in excellent physical condition. The subjects performed light, intermediate and heavy exercise on a bicycle ergometer while breathing air and during acute (15-30 minutes) and chronic (15-20 days) exposure to an ambient P sub CO2 of 21 mm Hg. Simultaneous measurements of V sub E, V sub O2, V sub CO2, pulse rate, rectal temperature, and arterial P sub O2, P sub CO2 and pH were made at rest and from the 12th-15th minute of steady state exercise in the supine P sub O2 position. Increases in V sub E, V sub O2 and V sub CO2 were linear in response to increasing work load for all experimental conditions, but the average magnitudes of these parameters at similar work loads were essentially equal in acute and chronic hypercapnia. At each work load average V sub E was higher and average V sub CO2 was lower in hypercapnia than the corresponding values in air. Average V sub O2 and pulse rate varied little for the same work load in the different experimental conditions. The differences between mean arterial P sub CO2 during acute and chronic hypercapnia and arterial P sub CO2 during air breathing increased progressively with increasing work load. Decreases in arterial pH from resting control values were also progressive with increasing work load, but were similar in magnitude for the three experimental conditions owing to differences in metabolic acidoses. Author

N71-20371*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

VOLITIONAL CONTROL OF VISUAL ACCOMMODATION

Robert J. Randle *In* AGARD Adaptation and Acclimatisation in Aerospace Med Mar 1971 13 p refs (See N71-20351 09-01) (NASA TM-X 66955) Avail NTIS CSCL 06P

Research was conducted in an attempt to show that volitional control is possible in most individuals when feedback is provided which indicates to the subject his present accommodation level. The feedback was provided by modulating an audio oscillator with the output of a servo-controlled infrared optometer which continuously

monitored the refractive state of the subject's eye. Six young males with normal vision were trained to control their accommodation first using a tone and then without it. A specific task they learned was to accommodate toward 0 diopters when a 3-diopter checkerboard target was extinguished and they viewed a dark empty field. Their performance was compared against six untrained subjects on two dark empty field test tasks. The tasks were (1) to maintain infinity focus while viewing a dark empty field for 3 minues and (2) to go to infinity focus from a 3-diopter target when it was extinguished and a dark field ensued during a 3 minute period. A statistical analysis of the results showed that the trained group made significant reductions in their dark field myopia under these conditions, but the untrained subjects did not. Author

N72-24058# Advisory Group for Aerospace Research and Development, Paris (France)
AEROMEDICAL HANDBOOK FOR AIRCREW
T. G. Dobie Mar. 1972 226 p
(AGARD-AG-154) Avail: NTIS HC $13.50

An aeromedical handbook, designed to provide information on the various aspects of aviation medicine that affect aircrew tasks, is presented. Data cover mental and physical health, effects of noise, survival measures, high altitude breathing, preventive medicine, and various other protective measures necessary for a safe flight. E.H.W.

N72-25031# Advisory Group for Aerospace Research and Development, Paris (France)
THE DISORIENTATION INCIDENT, PART 1
A. J. Benson, ed. (Royal Air Force Inst. of Aviation Med.) Mar. 1972 134 p refs Presented at Aerospace Med. Panel Specialist Meeting, Luchon, France, 28 Sep. 1971
(AGARD-CP-95-Pt-1) Avail: NTIS HC $8.75

The proceedings of a conference on spatial disorientation are presented. The subjects discussed are (1) description and analysis of disorientation incidents, (2) orientation error accidents, (3) training procedures, and (4) laboratory studies. The presentations were given in 16 reports. The principal findings and recommendations are summarized in a technical evaluation report. For individual titles, see N72-25032 through N72-25047.

N72-25032*# San Jose State Coll. Calif.
DISORIENTATION INCIDENTS REPORT BY MILITARY PILOTS ACROSS 14 YEARS OF FLIGHT
Brant Clark *In* AGARD The Disorientation Incident, Part 1 Mar. 1972 7 p refs (See N72-25031 16-04)
(Grant NGL-05-046-002)
(NASA-CR-126786) Avail: NTIS HC $3.00 CSCL 06S

The historical background of spatial disorientation problems among flying personnel is discussed. Recent incidents involving disorientation in flight were compared with incidents reported 14 years earlier. The incidents were very similar for various types of aircraft. The findings suggest that disorientation is currently experienced in a wide variety of flight operations and will continue to be experienced by flying personnel as an uncorrectable flight hazard. Author

N72-25033# Royal Air Force, Farnborough (England)
A REVIEW OF UNITED KINGDOM (RAF AND ARMY) STATISTICS ON SPATIAL DISORIENTATION IN FLIGHT 1960 - 1970
R. G. Lofting *In* AGARD The Disorientation Incident, Part 1 Mar. 1972 5 p (See N72-25031 16-04)
Avail: NTIS HC $8.75

An analysis of spatial disorientation incidents among pilots of the Royal Air Force is presented. Subjects discussed are (1) disorientation statistics, (2) aircraft types involved in disorientation occurrences, (3) classification of disorientation accidents, (4) classification of disorientation occurrences, and (5) relevant aircraft design features leading to disorientation. Author

N72-25034# Naval Aerospace Medical Research Lab., Pensacola, Fla.
ORIENTATION ERROR ACCIDENTS IN ARMY AVIATION AIRCRAFT
W. Carroll Hixson, Jorma I. Niven, and Emil Spezia (Army Board for Aviation Accident Res.) *In* AGARD The Disorientation Incident, Part 1 Mar. 1972 16 p refs (See N72-25031 16-04)
Avail: NTIS HC $8.75

To initiate the action necessary to establish the magnitude of the orientation-error problem in Army aviation, an interservice research program was organized under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory, the U. S. Army Board for Aviation Accident Research, and the Naval Aerospace Medical Research Laboratory. The first step was the construction of an operational definition of an orientation-error accident. The assimilation of data pertaining to the incidence and cause of such accidents and their actual and relative costs in terms of fatalities, injuries, and aircraft damage was then set as the working objective of the program. Accordingly, the decision was made to implement a five-year longitudinal study of all major and minor orientation-error accidents involving Army aviation flight operations beginning with July 1966. Incidence and cost data are presented for all Army aviation major and minor orientation-error accidents detected in the search of the accident files for the period July 1966 to July 1967. Separate and totalized statistical data are provided for fixed wing and rotary wing aircraft as well as for accidents occurring in Vietnam and those occurring elsewhere. Author

N72-25035# Bureau of Medicine and Surgery, Washington, D.C.
DISORIENTATION, FACT AND FANCY
Paul E. Tyler and Paul A. Furr *In* AGARD The Disorientation Incident Part 1 Mar. 1972 6 p refs (See N72-25031 16-04)
Avail: NTIS HC $8.75

The experiences of 2,000 naval aviators with disorientation during various flight conditions are presented. An analysis of all naval flight accidents for calendar year 1969 in which a disorientation incident contributed to the accident was made. It is shown that the majority of accidents coded as related to disorientation were erroneously coded. It was concluded that approximately 96 percent of aviators experience disorientation at some time, but that this disorientation contributes to a very small percentage of the accidents. Author

N72-25036# Naval Air Station, Norfolk, Va. Safety Center
PSYCHOPHYSIOLOGICAL AND ENVIRONMENTAL FACTORS AFFECTING DISORIENTATIONS IN NAVAL AIRCRAFT ACCIDENTS
Earl H. Ninow, William F. Cunningham, and Frederick A. Radcliffe *In* AGARD The Disorientation Incident, Part 1 Mar. 1972 4 p refs (See N72-25031 16-04)
Avail: NTIS HC $8.75

Psychophysiological and environmental factors, 12 in number, which most affect disorientation related mishaps are presented. These factors are listed in order of number of occurrence and it is indicated that often multiple factors are coded in conjunction with disorientation. Examples of disorientation related mishaps are presented to demonstrate psychophysiological and environmental factor involvement. A graph comparing attack and fighter pilot flight exposure to disorientation mishaps is charted to demonstrate the effect of experience upon control of disorientation. The chart indicates that flight experience does play a role in deterring of disorientation mishaps. Author

N72-25037# Naval Air Development Center, Johnsville, Pa. Crew Systems Dept.
DISORIENTING EFFECTS OF AIRCRAFT CATAPULT LAUNCHINGS
Malcolm M. Cohen, Richard J. Crosbie, and Laurence H. Blackburn *In* AGARD The Disorientation Incident, Part 1 Mar. 1972 6 p refs (See N72-25031 16-04)
Avail: NTIS HC $8.75

A human centrifuge facility was used to simulate the acceleration profiles encountered in aircraft catapult launchings Twelve subjects attempted to keep a continuously moving target at subjective eye level before, during, and after exposure to simulated catapult launch accelerations Results demonstrated that subjective eye level was changed by exposure to the accelerative forces The change in subjective eye level persisted, in some cases, for as long as three minutes after the simulated launch sequence was completed The results are discussed in terms of the effects of rotated acceleration vectors on human spatial orientation, and the data are related to certain types of aircraft losses that have been reported following catapult launchings at night Author

N72-25038# Aerospace Medical Research Labs, Wright-Patterson AFB, Ohio

EFFECTS OF ACOUSTIC STIMULI ON THE VESTIBULAR SYSTEM

C Stanley Harris *In* AGARD The Disorientation Incident, Part 1 Mar 1972 11 p refs (See N72-25031 16-04)

(AMRL-TR-71-58) Avail NTIS HC $8 75

The effects of noise intensity on the human vestibular system with resultant disorientation, nausea, and dizziness are discussed The response of human subjects to accustic stimuli was measured using nystagmorgraphy, vertical perception, and a rail test of human equilibrium Decrements in performance of 20 to 35 percent were obtained in high intensity noise of 140 decibels even when subjects wore ear protectors Sound levels as low as 100 decibels were found to produce an adverse effect on task performance It was also determined that noise levels affect human equilibrium at levels below those which will damage hearing Author

N72-25039# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

ALCOHOL INDUCED POSTROTATORY FIXATIONAL NYSTAGMUS. A TRAINING FILM ON A SIMPLE METHOD OF DETECTING SLIGHT ALCOHOLIC INTOXICATIONS IN PILOTS

G Froehlich *In* AGARD The Disorientation Incident, Part 1 Mar 1972 3 p refs (See N72-25031 16-04)

Avail NTIS HC $8 75

A method for detecting moderate alcoholic intoxication in human subjects is presented The method is based on observation of inability of intoxicated subject to suppress postrotatory fixational nystagmus The subject, in a standing position, is turned around his vertical axis five times within ten seconds with his eyes open in a normally illuminated room When the subject is stopped and asked to fix his vision on the examiner's finger held about 25 centimeters in front of his eyes, the intoxicated subject will be unable to fixate The method involved was demonstrated by a motion picture Author

N72-25040# Aerospace Medical Research Labs, Wright-Patterson AFB, Ohio

ANALYSIS OF THE VESTIBULO-OCULAR COUNTERROLL REFLEX IN PRIMATES

A M Junker, C R Replogle, K A Smiles, R D Brown, and R H Wheeler (AF Inst of Technol) *In* AGARD The Disorientation Incident, Part 1 Mar 1972 10 p refs (See N72-25031 16-04)

(AMRL-TR-71-59) Avail NTIS HC $8 75

The vestibulo-ocular reflex manifest by counterroll was used to determine the response dynamics of the vestibular system and alterations in these dynamics subsequent to +Gx acceleration exposure Six rhesus monkeys were tested before and after acceleration exposure to determine if significant changes had occurred in the vestibulo-ocular counterroll reflex The tests consisted of constant speed rotation, pendular oscillations and multiple sine wave oscillations about the subject's cyclopean axis Ocular counterroll was recorded using a linear resolver mechanically fixed to the monkey's eyeball There is no significant decrease in the system gain with inputs up to 1 Hz The observed phase lag can be accounted for by a time delay of approximately 0 2 seconds, and there is no significant response alteration caused by acceleration loading up to 75 +Gx Author

N72-25041# Advisory Group for Aerospace Research and Development, Paris (France)

TWO SPECIFIC KINDS OF DISORIENTATION INCIDENTS: JET UPSET AND GIANT HAND

R Malcolm and K E Money *In its* The Disorientation Incident, Part 1 Mar 1972 4 p refs (See N72-25031 16-04)

Avail NTIS HC $8 75

In certain circumstances (instrument flying conditions and severe turbulence), an inappropriate pilot input to aircraft controls leads to a dangerous nose down attitude of the aircraft There have been something in excess of 26 of these jet upsets In similar circumstances, there have been a few reports of what can be called the Giant Hand phenomenon, in which the pilot reports that the aircraft controls are forced into an extreme position and held there as if by a giant hand Precipitating circumstances and underlying mechanisms of these two kinds of incidents are discussed, and some unpublished experimental observations are presented Author

N72-25042# Royal Air Force Inst of Aviation Medicine, Farnborough (England)

SPATIAL DISORIENTATION AND THE BREAK-OFF PHENOMENA

A J Benson *In* AGARD The Disorientation Incident, Part 1 Mar 1972 11 p refs (See N72-25031 16-04)

Avail NTIS HC $8 75

Reports of aircraft pilots concerning occurrence of disorientation with subsequent feelings of unreality and detachment are analyzed It was determined that the reactions occurred during monotonous phases of flight in conditions where external visual orientation cues were restricted Evidence is presented which suggests the spatial disorientation occurring as a concomitant of break-off was caused by minor degrees of vestibular asymmetry The high incidence of anxiety reactions supports the view that in susceptible individuals break-off can be both a precipitant and a manifestation of anxiety neurosis Author

N72-25043# Naval Submarine Medical Center, Groton, Conn Research Lab

VERTIGO IN DIVERS

C F Gell *In* AGARD The Disorientation Incident, Part 1 Mar 1972 4 p refs (See N72-25031 16-04)

Avail NTIS HC $8 75

The occurrence of vertigo in hyperbaric atmospheres and with underwater divers is discussed Theories are presented to explain the etiology of these events Some of the theories are (1) barotrauma, (2) damage from the formation of bubbles, (3) hyperemia and hemorrhage, (4) unusual displacement of the stapes, (5) caloric stimulation, (6) slow movement of the ear drum and ossicles causing eddy currents, (7) performance of the valsalva maneuver, and (8) disturbed labrynthian function Author

N72-25044# Naval Aerospace Medical Research Lab, Pensacola, Fla

THEORY OF DEVELOPMENT OF REACTIONS TO WHOLE BODY MOTION CONSIDERED IN RELATION TO SELECTION, ASSIGNMENT, AND TRAINING OF FLIGHT PERSONNEL

Fred E Guedry, Jr *In* AGARD The Disorientation Incident, Part 1 Mar 1972 17 p refs (See N72-25031 16-04)

Avail NTIS HC $8 75

A speculative theory, dealing with the development of reactions to whole body motion, is outlined Functional aspects of reactions at several stages of maturation are considered in relation to conditioning mechanisms, which are, in turn, related to individual differences in development of motion reactivity, personality, and cognitive function Unnatural feedback resulting from passive motion is discussed in relation to different control

tasks performed in different job assignments and in relation to individual differences in reactions to motion Adaptation to the unnatural whole-body movement of flight is considered in this context and in relation to experiments illustrating that substantial changes in reactions to motion can be accomplished through habituation. Aviator selection tests, personality tests, flight aptitude tests, and several categories of training are considered in relation to the theoretical constructs. Author

N72-25045# Civil Aeromedical Inst., Oklahoma City, Okla. Psychology Lab

PRACTICAL TECHNIQUES FOR DISORIENTATION FAMILIARIZATION AND THE INFLUENCE OF VISUAL REFERENCE AND ALCOHOL ON DISORIENTATION-RELATED RESPONSES

William E Collins *In* AGARD The Disorientation Incident, Part 1 Mar 1972 10 p refs (See N72-25031 16-04)

Avail NTIS

Techniques and procedures for providing on-the-ground familiarization of aviation personnel with the effects of disorientation are discussed. The procedures are relatively inexpensive, effective for both participants and observers, and are readily accepted by aviators as pertinent to the aviation situation. The extent to which disorientation is affected by the type of visual information available to the pilot is examined under normal conditions and when alcohol is involved. Ways of demonstrating the deleterious effects of alcohol are described. Author

N72-25046# Royal Air Force Central Medical Establishment, London (England).

THE DISORIENTATION ACCIDENT: PHILOSOPHY OF INSTRUMENT FLYING TRAINING

T G Dobie *In* AGARD The Disorientation Incident, Part 1 Mar 1972 4 p refs (See N72-25031 16-04)

Avail NTIS HC $8.75

Patterns of disorientation occurrences in the United Kingdom RAF and Army for the period 1960-1970 are examined in order to formulate possible explanations and recommendations concerning, in particular, the philosophy of instrument flight training. The aircraft types most commonly involved and the circumstances confirm the likelihood of sensory incongruity being a contributory factor in the majority of cases. The underlying differences between primary and secondary disorientation are discussed. The predominant emphasis both in aeromedical indoctrination and instrument flying practice is concerned with preventing primary spatial disorientation, but insufficient effort is made towards ensuring that primary disorientation when it occurs, does not develop into the dangerous secondary stage. The various methods of simulation of instrument flying are examined. Author

N72-25047# Advisory Group for Aerospace Research and Development, Paris (France).

CLINICAL EVALUATION AND TREATMENT OF DISORIENTATION IN AIRCREW

P J OConnor *In its* The Disorientation Incident, Part 1 Mar 1972 6 p (See N72-25031 16-04)

Avail NTIS HC $8.75

The clinical evaluation and medical treatment of disorientation problems in flying personnel are discussed. It was determined that disorientation occurs most frequently in ages between 30 and 50. The symptoms were divided into (1) increased sensory input, (2) decreased sensory input, and (3) disturbed central thought processes. Treatment was by explanation and reassurance with the addition of rehabilitation flying and treatment of associated psychiatric disorders. Of the 90 cases treated, 54 returned to full flying duty. Author

N72-25048# Advisory Group for Aerospace Research and Development, Paris (France).

IMPROVED AND SIMPLIFIED METHODS FOR THE CLINICAL EVALUATION OF AIRCREW, PART 2

Heinz S. Fuchs, ed. (AF Hospital Inspection System, West Germany) Mar. 1972 81 p refs Mostly in ENGLISH, partly in FRENCH Presented at the Aerospace Med. Panel Specialist Meeting, Luchon, France, 29-30 Sep. 1971

(AGARD-CP-95-Pt-2) Avail: NTIS HC $6.25

Practical aeromedical requirements are discussed in the areas of cardiorespiratory assessment, anthropometric methods, biochemical analyses, X-ray examinations, and special visual investigation methods. For individual titles, see N72-25049 through N72-25060.

N72-25049# Beach Army Hospital, Fort Wolters, Tex.

MEDICAL ELIMINATION OF STUDENTS UNDERGOING PRIMARY FLIGHT TRAINING

Guthrie L. Turner, Jr. and Eric E. Lindstrom *In* AGARD Improved and Simplified Methods for the Clin Evaluation of Aircrew, Part 2 Mar. 1972 5 p refs (See N72-25048 16-04)

Avail: NTIS HC $6.25

A group of 5,278 student aviators were processed for primary helicopter training. All had undergone the initial Class 1 or 1A flight physical examination for flying and were found qualified. Students eliminated during calendar year 1970 from all causes totaled 1,410. Of this number 168 were eliminated for medical causes. Eye defects; ear, nose and throat defects, and neuropsychiatric abnormalities accounted for 53.8% of the medical eliminations. Of the 168 student aviators eliminated, 87 had medical defects that were probably detectable on the initial flight physical. Author

N72-25050# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

WHAT IS THE MEANING OF THE MASTER-STEP-TEST IN EXAMINATIONS TO DETERMINE THE FITNESS FOR MILITARY FLYING DUTY

H. W. Kirchhoff and A. Dietz *In* AGARD Improved and Simplified Methods for the Clin Evaluation of Aircrew, Part 2 Mar. 1972 3 p (See N72-25048 16-04)

Avail: NTIS HC $6.25

Long term examinations by means of an ECG were conducted on approximately 1000 pilots between 18 and 50 years of age. For the period of the past 14 years, at least 8 ECG's were obtained for each pilot. The examinations revealed the following results (1) Abnormal or conspicuous ECG alterations are found to a small extent in tests at rest and in master tests. (2) The number of conspicuous ECG findings increases with age. It became evident that special examinations, such as ergometer or hypoxia ECG, more frequently indicate abnormal ECG alterations than the routine procedures. Use of the master test is recommended only in routine examinations from the 35th year of age on. Author

N72-25051# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

USE OF LONGTERM ECG IN AVIATION MEDICINE

A. Dietz and H. W. Kirchhoff *In* AGARD Improved and Simplified Methods for the Clin Evaluation of Aircrew, Part 2 Mar. 1972 6 p refs (See N72-25048 16-04)

Avail. NTIS HC $6.25

A one-channel portable tape recording system for long term ECG recording is described. The possibilities of application of such a system in the examination and assessment of flying personnel is considered. Topics discussed include (1) supplementation of ECG diagnostics in examinations to determine fitness for military flying duty, (2) longitudinal observations for scientific clarification of certain ECG alterations, (3) inflight ECG examinations, and (4) heart rate registration during special examinations in aviation psychology, and training effects on heart rate. Author

N72-25052# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

THE AUTOMATIC ANALYSIS OF THE ECG AT REST, DURING AND AFTER EXERCISE WITH TWO DIFFERENT COMPUTER SYSTEMS

J. Zipfel, J. D. Meyer-Erkelenz, C. V. Kirschbaum, and H. W. Kirchhoff *In* AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2 Mar. 1972 6 p (See N72-25048 16-04)
Avail NTIS HC $6.25

The quality of various lead systems and computer programs for ECG diagnosis is considered. For the evaluation of the standard leads, the Minnesota system can be used. The program of Arvedson was used for the Frank system, which is particularly suitable for computer. The ECG was recorded at rest and during exercise to detect the beginning of coronary artery disease. The quantified ergometer work load was used as exercise. Attention was directed towards the evaluation of ST-T changes. The results were compared with the diagnosis of a cardiology team for the two computers. It is concluded that at rest and in the postexercise period, the use of both computer systems is justified. Author

N72-25053# School of Aerospace Medicine, Brooks AFB, Tex
EXTENDED ELECTROCARDIOGRAPHIC MONITORING WITH EMPHASIS ON COMPUTER ANALYSIS OF THE RECORDS
William H. Walter, III, Eric D. Grassman, Edward J. Engelken, and Malcolm C. Lancaster *In* AGARD Improved and Simplified Methods for the Clin Evaluation of Aircrew, Part 2 Mar. 1972 5 p refs (See N72-25048 16-04)
Avail NTIS HC $6.25

The use of continuous 6 to 8 hour tape-recorded electrocardiograms in the evaluation of patients with known or suspected cardiac disorders proved to be of value. All of the present commercially available equipment requires that a physician personally review each 6 to 8 hour tape. These tapes may be scanned at 36 to 60 times real time, and suspicious portions may be reproduced in equivalent real time. In an effort to accurately detect, count, and classify atypical ventricular depolarization complexes, an analog computer program was developed. Author

N72-25054# Royal Air Force Hospital, Wegberg (West Germany)
PROBLEMS IN THE CLINICAL ASSESSMENT OF RAISED ARTERIAL BLOOD PRESSURE IN AIRCREW
J. N. C. Cooke *In* AGARD Improved and Simplified Methods for the Clin Evaluation of Aircrew, Part 2 Mar 1972 3 p refs (See N72-25048 16-04)
Avail NTIS HC $6.25

The further assessment of apparently raised blood pressure levels found on routine examination of aircrew members is considered. The initial problem is posed by difficulties in establishing definite limits of normalcy and in fixing any level of blood pressure that divides health from disease. In the Royal Air Force, a consultant physician makes an initial clinical assessment and decides if there is a requirement for detailed investigation. This investigation consists of a standardized comprehensive search for possible causes for a rise in blood pressure and for associated pathological conditions. After this investigation a number of subjects remain whose fitness for further flying must be judged upon their blood pressure alone. These figures are subject to great variability, compounded by known factors of anxiety, tension, observer error, and environmental influences. Some of these problems might be reduced by repeated recordings under standardized conditions and the use of automatic cuff recorders in the hope that comparisons over varying time intervals may show up clear trends of improvement or deterioration in an individual. Final disposal still depends largely on the statistical evidence for increased mortality and morbidity associated with raised blood pressure levels and the resultant need to institute treatment. Author

N72-25055# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
A SIMPLIFIED AND IMPROVED METHOD FOR OPERATIONAL ANTHROPOMETRIC PROGRAMMES c05
H. J. Grunhofer *In* AGARD Improved and Simplified Methods for the Clin Evaluation of Aircrew, Part 2 Mar 1972 8 p
Avail NTIS HC $6.25

The operational significance of antropometric data is demonstrated by an example of consequences following the introduction of an ejection seat in an aircraft. Several simplified measuring devices and techniques are discussed. A device for the application of anthropometric data and for medical re-evaluation of pilots with possible functional impairments is discussed. Author

N72-25056# Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France).
RADIOLOGICAL EXAMINATION OF THE SPINE AND THE COMBAT PILOT'S CAPABILITY FOR DUTY [EXAMEN RADIOLOGIQUE DU RACHIS ET APTITUDE A L'EMPLOI DE PILOTE DE COMBAT]
R. P. Delahaye, G. Gueffier, and P. J. Metges *In* AGARD Improved and Simplified Methods for the Clin Evaluation of Aircrew, Part 2 Mar 1972 10 p refs In FRENCH (See N72-25048 16-04)
Avail NTIS HC $6.25

The radiological examination of the spine during entrance fitness examinations of flying personnel is discussed. The limiting scoliotic angle for combat flight was determined to be 10 degrees, beyond which there is danger of injury in the case of ejection from the aircraft. Transl by K.P.D.

N72-25057*# National Aeronautics and Space Administration, Washington, D.C.
A SIMPLIFIED SPACE TECHNOLOGY METHOD FOR CLINICAL AIRCREW MEASUREMENT OF FUNCTIONAL RESPIRATORY VALUES
Walton L. Jones and B. M. Bushman (Parkin-Elmer Corp., Pomona, Calif.) *In* AGARD Improved and Simplified Methods for the Clin Evaluation of Aircrew, Part 2 Mar 1972 11 p (See N72-25048 16-04)
(NASA-TM-X-68370) Avail NTIS HC $3.00 CSCL 06E

A versatile, rapid, reliable respiratory gas analyzer based on mass spectrometer principles was developed for air crew pulmonary function measurement. The instrument can provide a continuous and simultaneous analysis of up to eight gases useful in pulmonary function evaluation. The principal gases include oxygen, carbon dioxide, nitrogen, and water vapor. The instrument is suited to air crew and space cabin applications because (1) The quantity of gas diverted to the mass spectrometer is a negligible fraction of the expired gas. (2) The time response of the mass spectrometer is fast relative to the breath cycle time. (3) The mass spectrometer is capable of accurate partial pressure measurements. (4) The size, weight, and power requirements are compatible with most in-flight applications. (5) Simplicity and reliability of operation are stressed. Author

N72-25058# Royal Air Force, Farnborough (England) Central Medical Establishment
IMPROVED METHODS OF CLINICAL ELECTRODIAGNOSIS IN PROGNOSIS OF LOWER MOTOR NEURONE LESIONS
C. B. Wynn-Parry *In* AGARD Improved and Simplified Methods for the Clin Evaluation of Aircrew, Part 2 Mar 1972 4 p refs (See N72-25048 16-04)
Avail NTIS HC $6.25

Techniques in electromyography are discussed in connection with the diagnosis of lower motor neurons lesions. Various lesions and their symptoms are considered. K.P.D.

N72-25059# Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)
INTEREST IN MEASURING RESISTANCE TO VERTIGO AMONG FLYING PERSONNEL [INTERET DE LA MESURE DE LA RESISTANCE A L'EBLOUISSEMENT CHEZ LES MEMBRES DU PERSONNEL NAVIGANT]
J. P. Chevaleraud and G. Perdriel *In* AGARD Improved and Simplified Methods for the Clin Evaluation of Aircrew, Part 2 Mar 1972 3 p In FRENCH (See N72-25048 16-04)
Avail NTIS HC $6.25

A simple method is presented which permits the evaluation

of aptitude for regaining visual function while being subjected to vertigo. The orientation of the subject and authorization for revocation of flight activities when an ocular affection is involved are considered. Transl. by K.P.D.

N72-26060# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

ALCOHOL INDUCED POSTROTATORY FIXATIONAL NYSTAGMUS. A TRAINING FILM ON A SIMPLE METHOD OF DETECTING SLIGHT ALCOHOLIC INTOXICATIONS IN PILOTS

G. Froehlich *In* AGARD Improved and Simplified Methods for the Clin. Evaluation of Aircrew, Part 2 Mar. 1972 11 p refs (See N72-26046 16-04)

Avail: NTIS HC $6.25

A film showing the practical procedure and its nystagmographical correlates is discussed. With this test, the flight surgeon has at his disposal a reliable and simple method to detect and thus eliminate from duty flying pilots in an acute state of alcohol intoxication or with a marked hangover from the night before. Author

N72-26045# Advisory Group for Aerospace Research and Development, Paris (France).

SPECIAL BIOPHYSICAL PROBLEMS IN AEROSPACE MEDICINE, PART 3

A. M. Pfister, ed. Mar 1972 126 p refs Partly in ENGLISH and FRENCH Presented at Aerospace Med. Panel Specialist Meeting, Luchon, France, 30 Sep. - 1 Oct. 1971

(AGARD-CP-95-Pt-3) Avail: NTIS HC $8.50

A biophysical approach to solving the problems faced by man when exposed to cosmic rays, electromagnetic waves, magnetic fields, and laser radiation is summarized. For individual titles, see N72-26046 through N72-26057.

N72-26046# Kiel Univ. (West Germany)

PRESENT KNOWLEDGE OF COSMIC RAYS

O. C. Allkofer *In* AGARD Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar 1972 14 p refs (See N72-26045 17-04)

Avail: NTIS HC $8.50

The main features of cosmic radiation are outlined as far as they are of interest concerning radiation hazards in SST and manned space flights. The properties of the galactic and solar component and of the radiation belts are characterized. The interactions of the primary particles with the atmosphere and the earth's magnetic field are illustrated and figures are given for the altitude and latitude dependence. Finally, the modulation effects of the galactic component due to the solar influence are discussed. Author

N72-26047# Atomic Weapons Research Establishment, Aldermaston (England). Radiation Measurements Section.

ACTIVE DOSIMETRY OF COSMIC RADIATION

E. W. Fuller *In* AGARD Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar 1972 11 p refs (See N72-26045 17-04)

Avail: NTIS HC $8.50

The role assumed for active dosimetry in manned space missions and high altitude flight is to enable the exposure received during flight to be controlled by on-board monitoring. The radiation environment and the need for active dosimetry in the two circumstances are reviewed and then the instrumentation available and under development for this application is described. Methods of calibrating such instrumentation are also considered. It is concluded that satisfactory instruments for both applications are presently available but that there is a need for continuing development of more compact systems for high altitude aircraft. Author

N72-26048# Centre de Recherches Nucleaires, Strasbourg (France). Lab. de Physique Corpusculaire

PASSIVE DOSIMETRY OF COSMIC RADIATION [DOSIMETRIE PASSIVE DU RAYONNEMENT COSMIQUE]

R. Kaiser *In* AGARD Spec. Biophys. Probl. in Aerospace Med., pt. 3 Mar. 1972 9 p In FRENCH (See N72-26045 17-04)

Avail: NTIS HC $8.50

The use of passive dosimetry to study the biological effects of cosmic radiation is discussed. The problems and functions of using such equipment are also examined. Experimental dose rates were calculated and compared to measured ones. Results are given in tables. Transl. by E.H.W.

N72-26049# Centre d'Enseignement et de Recherches de Medecine Aeronautique, Paris (France)

SOME CONSIDERATIONS ON THE DIFFICULTIES OF DOSIMETRIC EVALUATION AND COSMIC RADIATION INJURIES [QUELQUES CONSIDERATIONS SUR LES DIFFICULTES DE L'EVALUATION DOSIMETRIQUE ET LESIONNELLE DES RADIATIONS COSMIQUES]

S. Despres, C. Nogues, and G. Deltour *In* AGARD Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar. 1972 6 p In FRENCH (See N72-26045 17-04)

Avail: NTIS HC $8.50

The difficulties encountered in the dosimetric evaluation of cosmic rays and their effect on living matter are reported. Data cover the effects of heavy ions on skin pigments, nervous tissue, human cells in culture, biological molecules, and microorganisms. Transl. by E.H.W.

N72-26050# Toulouse Univ. (France). Lab. de Biologie Medicale

EVIDENCE ON THE EFFECT OF NATURAL IONIZING RADIATION ON BIOLOGICAL STIMULATION [MISE EN EVIDENCE D'UN EFFET BIOLOGIQUE DE STIMULATION DES RADIATIONS IONISANTES NATURELLES]

H. Planel, J. P. Soleilhavoup, R. Tixador, M. C. Giess, and F. Croute *In* AGARD Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar. 1972 12 p refs In FRENCH (See N72-26045 17-04)

Avail: NTIS HC $8.50

The effects of radioprotection and very weak irradiations on unicellular organism multiplication and embryonic development of Drosphila melonogaster are studied. Results show that in unicellular organisms, irradiation prolonged the cellular cycle and reduced multiplication. When the organisms were returned to a radioprotected environment, their multiplication and cellular cycles returned to normal. In the fruit fly, radiation exposure caused prolonged embryonic and larvae development. Transl. by E.H.W.

N72-26051*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

VISUAL PHENOMENA INDUCED BY COSMIC RAYS AND ACCELERATED PARTICLES

Cornelius A. Tobias, Thomas F. Budinger, John T. Leith, Abdel-Megid Mamoon, and Philip Chapman *In* AGARD Spec. Biophys. Probl. in Aerospace Med., Pt. 3 Mar. 1972 12 p refs Prepared in cooperation with Calif. Univ., Berkeley (See N72-26045 17-04)

(NASA-TM-X-68460) Avail: NTIS HC $3.00 CSCL 06R

Experiments, conducted at cyclotrons together with observations by Apollo astronauts, suggest with little doubt that cosmic nuclei interacting with the visual apparatus cause the phenomenon of light flashes seen on translunar and transearth coast over the past four Apollo missions. Other experiments with high and low energy neutrons and a helium ion beam suggest that slow protons and helium ions with a stopping power greater than 10 to the 8th power eV/gram sq cm can cause the phenomenon in the dark adapted eye. It was demonstrated that charged particles induced by neutrons and helium ions can stimulate the visual apparatus. Some approaches to understanding the long term mission effects of galactic cosmic nuclei interacting with man and his nervous system are outlined. Author

N72-26052# Centre de Recherches Nucleaires, Strasbourg (France). Lab. de Physique Corpusculaire

FIRST RESULTS OF PASSIVE DOSIMETRIC COSMIC RADIATION EFFECTS ONBOARD A PROTOTYPE OF THE CONCORDE 001 SUPERSONIC TRANSPORT [PREMIERS RESULTATS DE LA DOSIMETRIE PASSIVE DU RAYONNEMENT COSMIQUE EFFECTURE A BORD DU PROTOTYPE DE L'AVION DE TRANSPORT SUPERSONIQUE CONCORDE 001]
R Kaiser, A M Pfister, and R P Delahaye *In* AGARD Spec Biophys Probl in Aerospace Med Pt 3 Mar 1972 10 p refs In FRENCH (See N72-26045 17-04)
Avail NTIS HC $8 50

After a description of the characteristics of passive dosimetry carried out with the aid of equipment installed onboard a French prototype of the Concorde supersonic transport aircraft, the methods used to calculate the cosmic radiation dose rates and the results obtained are given. A preliminary interpretation of dose rates was made and compared to those obtained in an English prototype. The results from this comparison show the dose rates are in agreement
Transl by E H W

N72-26053# Service de Sante des Armees, Toulon (France)
BIOLOGICAL EFFECTS OF UHF ELECTROMAGNETIC RADIATION [EFFETS BIOLOGIQUES DES RAYONNEMENTS ELECTROMAGNETIQUES UHF (RADARS)]
R Joly and B Servantie *In* AGARD Spec Biophys Probl in Aerospace Med, Pt 3 Mar 1972 14 p refs In FRENCH (See N72-26045 17-04)
Avail NTIS HC $8 50

Very high frequency radiation effects, emitted by radar equipment, on the human organism are investigated. The physiological and physiopathological aspects are outlined. Data also cover pulse duration, penetrative power, energy density and exposure time
Transl by E H W

N72-26054# Bureau of Medicine and Surgery, Washington, D C
THE US NAVY'S PROGRAM IN NONIONIZING RADIATION
Paul E Tyler *In* AGARD Spec Biophys Probl in Aerospace Med, Pt 3 Mar 1972 4 p refs (See N72-26045 17-04)
Avail NTIS HC $8 50

The extent of dependence of military forces upon electromagnetic radiation emitters for their day to day operations is discussed. The current concepts and safety standards of the Eastern European countries are reviewed briefly. The current Navy program in the area of nonionization radiation is presented. Three major approaches are emphasized (1) basic research (2) exploratory research, and (3) epidemiological surveys. The lack of adequate dosimetric instrumentation is discussed and the current program to develop instrumentation is presented
Author

N72-26055*# Naval Aerospace Medical Research Lab Pensacola, Fla
MAGNETIC FIELDS AND MAN: WHERE DO WE STAND TODAY?
Dietrich E Beischer and Vernon R Reno *In* AGARD Spec Biophys Probl in Aerospace Med, Pt 3 Mar 1972 9 p refs
Sponsored in part by NASA (See N72-26045 17 04)
(NASA-CR-127049) Avail NTIS HC $3 00 CSCL 06R

An assessment is made of the effects of very low and very high magnetic fields on man. In preparation for the Apollo flights, magnetic fields of 50 gamma were generated in the laboratory by two different methods. Human volunteers were tested with a comprehensive battery of physiological and psychological tests during and after continuous exposure for various time periods. No significant difference due to the low field was found for exposure periods of up to 10 days. Technological advancements in power generation, antisubmarine warfare and energy storage and transmission expose man to magnetic fields many orders of magnitude higher than those heretofore encountered. The only available information relevant to these conditions is based upon occasional observations in high energy physics laboratories and Soviet descriptions of clinical effects. Results of incidental human exposure and of primates exposed to high fields indicate that, while actual survival is not threatened by such exposures, high fields can influence man to a degree sufficient to cause serious performance decrement
Author

N72-26056# Duke Univ, Durham, N C Dept of Ophthalmology
LASER SAFETY AND HOW TO PROMOTE IT
Myron L Wolbarsht *In* AGARD Spec Biophys Probl in Aerospace Med, Pt 3 Mar 1972 6 p refs (See N72-26045 17-04)
(Contract N00014-67-A-0251-0011)
Avail NTIS HC $8 50

The characteristics of lasers which may produce danger are briefly discussed with regard to the special characteristics of laser light and also the characteristics they share with other light sources. Types of personnel protection are considered as are regulations and safety programs in relation to the energy and power levels that are currently thought to be nonhazardous. The principles of hazard analysis are described in conjunction with their use at any particular safety level. Two of the programs carried on by the U S Navy Medical Department on laser safety are considered in detail. One deals with the functional decrement in visual acuity of monkeys by pulsed laser trains in the near infrared. The other is concerned with the determination of threshold levels for ocular injury by lasers in human volunteers
Author

N72-26057# Royal Air Force Inst of Aviation Medicine, Farnborough (England)
LASER SAFETY: SOME CONSIDERATIONS IN THE DESIGN OF A CODE OF PRACTICE
R G Borland *In* AGARD Spec Biophys Probl in Aerospace Med, Pt 3 Mar 1972 13 p refs (See N72-26045 17-04)
Avail NTIS HC $8 50

Military and industrial research on a safety code for the use of laser equipments is outlined. Data cover safe thresholds, methods for measuring these thresholds, and characteristics of the laser to be used. Special attention is given to retina damage in the operators
E H W

N73-17098# Advisory Group for Aerospace Research and Development, Paris (France)
AEROMEDICAL ASPECTS OF VIBRATION AND NOISE
J C Guignard and P F King Nov 1972 280 p refs
(AGARDograph-151, AGARD-AG-151) Avail NTIS HC $16 00

Effects of aerospace vibration and noise on man are considered. The special aeromedical problems of auditory perception and noise injuries in aircrew and ground support personnel are emphasized. For individual titles, see N73-17099 through N73-17101

N73-17099 Wright State Univ, Dayton, Ohio Dept. of Engineering
VIBRATION
J C Guignard *In* AGARD Aeromed Aspects of Vibration and Noise Nov 1972 p 1-113 refs (For availability see N73-17098 08-04)

The nature of structure-borne vibration and its occurrence in aerospace operations are considered by mechanical and biological actions upon man, and by the criteria and principles of protecting man from its adverse effects
Author

N73-17100 Wright State Univ, Dayton, Ohio
NOISE
J C Guignard *In* AGARD Aeromed Aspects of Vibration and Noise Nov 1972 p 114-203 refs (For availability see N73-17098 08-04)

Nature, measurement and occurrence of airborne noise in aerospace operations are considered by the biological effects on man. General criteria and principles of the protection of man from the adverse effects of noise on human well being and working efficiency are outlined
Author

N73-17101 Royal Air Force Central Medical Establishment, London (England).
HEARING CONSERVATION IN AIRCREW AND GROUND SUPPORT PERSONNEL
P. F. King *In* AGARD Aeromed. Aspects of Vibration and Noise Nov. 1972 p 204-257 refs (For availability see N73-17098 08-04)

The effects of noise on human hearing, both temporary and permanently, are reviewed and related to the working situations of members of aircrews and ground support personnel. Measures to be taken to prevent noise damage in the peripheral parts of the human hearing mechanism and to conserve hearing in personnel exposed to hazardous noise levels are outlined
Author

N73-17106# Advisory Group for Aerospace Research and Development, Paris (France)
SPECIAL ASPECTS OF AVIATION OCCUPATIONAL MEDICINE. CARDIOVASCULAR AND NERVOUS SYSTEM EFFECTS OF BROMOTRIFLUOROMETHANE
K. C. Back (AMRL) and E. W. VanStee (AMRL) Nov. 1972 20 p refs
(AGARD-R-599) Avail NTIS HC $3.00

The effects of three fluorocarbons of the haloalkane group, principally with bromotrifluoromethane, which have applications as effective fire extinguishing agents are studied Animal experiments, performed to explore the mechanisms of the pharmacodynamic properties and to assess the toxic hazards associated with their use, are described All three compounds have biological side effects and the report provides preliminary information derived from animal experiments, on acceptable working concentrations for human exposure
Author

N73-19065# Advisory Group for Aerospace Research and Development, Paris (France)
COLOUR VISION REQUIREMENTS IN DIFFERENT OPERATIONAL ROLES
Nov. 1972 83 p refs In ENGLISH, partly in FRENCH Presented at AGARD Aerospace Med Panel Specialist Meeting, Brussels, 30 May 1972
(AGARD-CP-99) Avail NTIS HC $6.25

Proceedings are presented on the theoretical and practical aspects of color vision, the rationale of color vision requirements for air and ground crews, and color vision testing The requirements for flying personnel of the armed forces for many nations are emphasized For individual titles, see N73-19066 through N73-19076

N73-19066* Duke Univ., Durham, N.C. Dept. of Ophthalmology
THEORETICAL ASPECTS OF COLOR VISION
Myron L. Wolbarsht *In* AGARD Colour Vision Requirements in Different Operational Roles Nov. 1972 10 p refs (For availability see N73-19065 10-04)
(Contract NAS9-11294)

The three color receptors of Young-Helmholtz and the opponent colors type of information processing postulated by Hering are both present in the human visual system. This mixture accounts for both the phenomena of color matching or hue discrimination and such perceptual qualities of color as the division of the spectrum into color bands. The functioning of the cells in the visual system, especially within the retina, and the relation of this function to color perception are discussed
Author

N73-19067 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany) Opthalmological Branch
PRACTICAL ASPECTS OF COLOR VISION AND ITS DISTURBANCE
Dietrich Kuerschner *In* AGARD Colour Vision Requirements in Different Operational Roles Nov. 1972 8 p refs (For availability see N73-19065 10-04)

A number of specialists of the German Air Force, except the flying personnel, were assessed to determine the extent of color vision required It is shown that normal color vision is mandatory only for the activities of the telephone technician and the telephone ...
Author

N73-19068 Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)
EXAMINATION OF CHROMATIC SENSE IN FRENCH AERIAL FORCES [L'EXAMEN DU SENS CHROMATIQUE DANS LES FORCES AERIENNES FRANCAISES]
G. Perdriel and J. Chavaleraud *In* AGARD Colour Vision Requirements in Different Operational Roles Nov. 1972 5 p In FRENCH (For availability see N73-19065 10-04)

A procedure was developed to test the chromatic aptitude of dyschromatopsia victims who wanted positions as navigators or pilots in France Security procedures using such personnel and a color signaling process to aid them in perceiving colors are discussed
Transl. by E.H.W.

N73-19069 School of Aerospace Medicine, Brooks AFB, Tex Ophthalmology Branch
HISTORY, RATIONALE, AND VERIFICATION OF COLOR VISION STANDARDS AND TESTING IN THE UNITED STATES AIR FORCE
Thomas J. Tredici, James L. Mims, III, and James F. Culver *In* AGARD Colour Vision Requirements in Different Operational Roles Nov. 1972 10 p refs (For availability see N73-19065 10-04)

The color vision testing and selection procedures utilized in World War II by the US Army Air Corps are reviewed The color vision standards for flying in the US Air Force recently were changed for the first time since World War II. M... defectives scoring 50 or better on the SAM color threshold tester are now accepted into flying training A ten-year retrospective study of 4801 experienced flying personnel provides strong evidence that these standards are valid The handling of color vision defective cases is also outlined
Author

N73-19070 National Defence Medical Centre, Ottawa (Ontario) Dept. of Ophthalomology
COLOUR VISION IN THE CANADIAN ARMED FORCES
Bryan St. L. Liddy *In* AGARD Colour Vision Requirements in Different Operational Roles Nov. 1972 6 p (For availability see N73-19065 10-04)

Color vision in the Canadian Armed Forces is reviewed, including their standard tests Ishihara standards book test, Green Edwards lantern test, and A O isochromatic book test Different requirements of color vision for the various service branches are described Minimum color vision standards for the initial assignment to trades within the armed forces are listed in tabular form
IAM

N73-19071 Centre de Medecine Aeronautique, Brussels (Belgium)
STANDARDIZATION OF TEST AND CATEGORIZATION OF COLOR VISION ANOMALIES IN MILITARY CIRCLES, AND METHODS USED BY EMPLOYEES TO TRACK DOWN THEIR PROBLEMS [ESSAI DE STANDARDISATION DE LA CATEGORISATION DES ANOMALIES DE LA VISION DES COULEURS EN MILIEU MILITAIRE, AINSI QUE DES METHODES EMPLOYEES EN VUE DE LEUR DEPISTAGE]
J. M. VanDeCasteele *In* AGARD Colour Vision Requirements in Different Operational Roles Nov. 1972 4 p In FRENCH (For availability see N73-19065 10-04)

Sound scientific procedures developed to categorize color vision abnormalities in a uniform manner are discussed The classification of individuals was made as a function of the number of error responses to tests, the nature of the abnormality and the gravity of the condition
Transl. by E.H.W.

N73-19072 Royal Air Force Inst. of Aviation Medicine, Farnborough (England)
COLOUR VISION REQUIREMENTS IN DIFFERENT OPERATIONAL ROLES
D. H. Brennan *In* AGARD Colour Vision Requirements in Different Operational Roles Nov. 1972 3 p refs (For availability see N73-19065 10-04)

Color vision in the various operational roles of the Royal Air Force and Army Air Corps was studied It is considered that good color acuity, although playing a valuable part in the total process of visual perception is not of paramount importance. It

would be possible by altering the present chromaticities of red and green signal colors to admit for all aircrew duties, except those of close air support, the more severe grades of red green defective. It is thought, however, that the small gain in recruiting would not warrant the resulting expense and disruption of present services. The pseudo-isochromatic plates provide a simple and rapid method of detecting even minor anomalies of color vision. With present standards, the lantern is the best trade test for grading color defectives as fit or unfit for aircrew duties. Should standards be lowered it would be necessary to supplement the lantern with a quantitative test which should be related, if possible, to the role envisaged for the candidate. Author

N73-19073 Army Aeromedical Research Lab., Fort Rucker, Ala.
AIRCREW COLOR VISION REQUIREMENTS
Robert W. Bailey *In* AGARD Colour Vision Requirements in Different Operational Roles Nov. 1972 4 p (For availability see N73-19065 10-04)

A study revealed no statistical difference in accident rates between a selected population of color defectives and a matched sample of normals. The only significant difference demonstrated was between serious accidents in which the color normals were involved in a greater number of accidents (statistically significant) than color defectives. Operational testing of difficult cases are also presented. Author

N73-19074 Walter Reed Army Medical Center, Washington, D.C.
PREDICTING VISUAL PERFORMANCE IN AVIATORS (COLOR VISION)
Budd Appleton *In* AGARD Colour Vision Requirements in Different Operational Roles Nov 1972 5 p (For availability see N73-19065 10-04)

The whole concept of physical standards for personnel selection is reviewed, emphasizing visual performance for aviators. Color vision tests as predictive indicators of flying task performance are evaluated. Experience with a battery of tests as part of an aeromedical in-flight evaluation is recorded in tabular form for 12 aviators. J.A.M.

N73-19075 Headquarters Army Aviation, Middle Walloo (England). Dept. of Aviation Medicine.
HELICOPTER FLYING AND COLOUR VISION
I. C. Perry *In* AGARD Colour Vision Requirements in Different Operational Roles Nov. 1972 4 p refs (For availability see N73-19065 10-04)

When problems are encountered in low level helicopter flying, under poor light and in featureless terrain, difficulties arise where colors have to be used for information presentation and to isolate certain items of information. Instrument lighting, map colors and marking can all become problem areas when the operators color vision is abnormal. Differences are found in methods of color vision testing. The use of colored smokes against varying backgrounds can lead to mistakes, as can wiring diagrams and wire markings. Author

N73-19076 Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.
COLOR VISION REQUIREMENTS FOR AIR CREW PERSONNEL OF THE FUTURE
Walter F. Grether *In* AGARD Colour Vision Requirements in Different Operational Roles Nov. 1972 7 p refs (For availability see N73-19065 10-04)
(AMRL-TR-71-118)

Color has unique value as a means of coding visually presented information. This was shown by experimental evaluations of alternate coding methods, such as pattern, size, intensity and flash rate. A reduction in color vision selection standards for flight personnel, such as the pilot, would require the replacement of color with other and potentially less efficient visual coding methods. Such a change would restrict the visual display choices available to the designers of future information presentation equipment, both airborne and ground. An examination of past trends and current equipment development indicates that the use of color for coding information used by flight personnel will probably be increasing rather than decreasing in the future. Author

N73-21092# Advisory Group for Aerospace Research and Development, Paris (France).
PREDICTABILITY OF MOTION SICKNESS IN THE SELECTION OF PILOTS
M. P. Lansberg, ed. Feb. 1973 69 p refs Partly in ENGLISH, partly in FRENCH Proc. of Aerospace Med. Panel Specialist Meeting, Glasgow, 7 Sep. 1972
(AGARD-CP-109) Avail: NTIS HC $5.50

Susceptibility and factors contributing to motion sickness are examined. The Air Force and Navy tests for motion sickness predictions are described. Drugs that counteract the air sickness are considered. Blind fish responses to gravitational changes during parabolic flight are also studied. For individual titles, see N73-21093 through N73-21101.

N73-21093 Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).
MEASUREMENT OF SUSCEPTIBILITY TO MOTION SICKNESS
K. E. Money *In* AGARD Predictability of Motion Sickness in the Selection of Pilots Feb. 1973 4 p refs (For availability see N73-21092 12-04)

Three different bases were suggested for predicting susceptibility to motion sickness in a specific vehicle. These are (1) history of motion sickness, (2) susceptibility to motion sickness in a laboratory device, and (3) laboratory vestibular and other tests. These techniques were reviewed, and their usefulness was assessed. It was concluded that the laboratory vestibular and other tests are without practical value. Susceptibility to motion sickness laboratory devices and history of motion sickness were used and have significant predictive value. Consideration of these techniques for selection of aircrew candidates includes a comparison of the economic and other advantages of elimination of most air sickness problems and the disadvantages of the testing expense and the loss of some candidates who would not actually have had difficulty with motion sickness. Author

N73-21094 Centre d'Etudes et de Recherches de Medecine Aeronautique, Paris (France).
POSSIBILITY OF PREDICTING PREDISPOSITION OF MOTION SICKNESS IN THE SELECTION OF PILOTS [POSSIBILITE DE PREVOIR LA PREDISPOSITION AU MAL DES TRANSPORTS LORS DE LA SELECTION DES PILOTES]
G. Leguay, J. C. Hadni, M. Gouars, R. Gelly, and A. P. Gibert *In* AGARD Predictability of Motion Sickness in the Selection of Pilots Feb. 1973 9 p In FRENCH (For availability see N73-21092 12-04)

The medico-aeronautical basis of selecting pilot personnel in relation to motion sickness is outlined. Human factors, aeronautical factors, and natural evolution of motion sickness in the pilots are described in detail. Selection techniques cover neuromuscular, neurovegetative, and psychological examinations, and flight experience. Transl. by E.H.W.

N73-21095 Leicester Univ. (England). Dept. of Psychology.
FACTORS CONTRIBUTING TO MOTION SICKNESS SUSCEPTIBILITY: ADAPTABILITY AND RECEPTIVITY
James Reason (Naval Aerospace Med. Res. Lab., Pensacola, Fla.) and Ashton Graybiel *In* AGARD Predictability of Motion Sickness in the Selection of Pilots Feb. 1973 15 p refs (For availability see N73-21092 12-04)

Evidence is presented to show that two perceptual factors, receptivity and adaptability, contribute to variation in motion sickness susceptibility. An attempt is made to integrate these two sources of variation into a neural mismatch theory of motion sickness. Two original studies are briefly reported. In the first, positive and significant relationships were obtained between measures of adaptability and (1) a personal history measure of susceptibility, (2) loss of well being during exposure to cross-coupled angular accelerations, and (3) a questionnaire measure of introversion. It was also found that adaptability and receptivity

are unrelated factors, and that, of the two, adaptability exerted the most potent influence upon susceptibility. Yet, among slow adapters only, there was some evidence to show that receptivity contributed to individual differences in proneness. The second study was concerned with the long-term retention of protective adaptation. Author

N73-21096 Naval Aerospace Medical Research Lab., Pensacola, Fla.

ASSESSMENT OF REACTIONS TO VESTIBULAR DISORIENTATION STRESS FOR PURPOSES OF AIRCREW SELECTION

Fred E. Guedry and Rosalie K. Ambler *In* AGARD Predictability of Motion Sickness in the Selection of Pilots Feb. 1973 8 p refs (For availability see N73-21092 12-04)

Several tests were described which are useful for predicting individuals who will separate from air training because of airsickness and/or disabling anxiety toward flight. These tests are based on measures of immediate reactions to disorientation stress. It is desirable to have a futher diagnostic assessment of individuals to determine the underlying causes of differences in reactivity to disorientation stress and also to estimate the individual's likelihood of success in the light of other predictor variables. The disorientation stress tests significantly augment other aviator predictor variables, and they appear to be significantly correlated to several personality measures. A particular visual display and task were used that produced significantly more sickness than did other tasks during comparable vestibular stimulation. The test procedure was changed and a procedure was developed which appears practical for assessing individual differences in accommodation to intersensory conflict between the visual and vestibular systems. The changed procedure did not produce sickness, and the results indicate that a 57 per cent mean improvement in visual performance during vestibular stimulation can occur after only a 10-minute habituation schedule. At least part of the improvement in visual performance appears attributable to increased visual control over vestibular reflex control of the eyes. Author

N73-21097 Naval Aerospace Medical Research Lab., Pensacola, Fla.

MOTION SICKNESS QUESTIONNAIRE AND FIELD INDEPENDENCE SCORES AS PREDICTORS OF SUCCESS IN NAVAL AVIATION TRAINING

Robert S. Kennedy *In* AGARD Predictability of Motion Sickness in the Selection of Pilots Feb. 1973 5 p refs (For availability see N73-21092 12-04)

The usefulness of two paper and pencil tests in predicting the likelihood of success in Naval aviation training is reported. Several years experience with a motion sickness questionnaire is reviewed. literature and theories related to motion sickness are surveyed, and a group-administered personality test is reported. The motion sickness questionnaire (MSQ) was empirically validated against an experimental procedure for producing motion sickness symptomatology (N = 100), and in a larger group (N = 802) scores on the questionnaire were statistically related to the likelihood of aviation training success. Refinements in the scoring improved the predictive ability of the MSQ (N = 660) and cross-validated successfully (N = 550). Author

N73-21098 School of Aerospace Medicine, Brooks AFB, Tex. Biodynamics Branch

THE USAFSAM SELECTION, TEST, AND REHABILITATION PROGRAM OF MOTION SICK PILOTS

Patrick J. Dowd *In* AGARD Predictability of Motion Sickness in the Selection of Pilots Feb. 1972 10 p refs (For availability see N73-21092 12-04)

The USAF School of Aerospace Medicine biaxial stimulator was used to impose standardized Coriolis stimuli for the purpose of determining a subject's tolerance of this very disturbing stimulus. This test differentiates the nonsick (NS) individuals from the sick (S) ones within each peer group (navigators, pilots, and airman trainees) and is a valuable indicator of the level of resistance an individual has to Coriolis accelerations and as a selection tool for an individual's resistance to motion sickness. The results of this type of test (pilots NS-299, S-51; navigators NS-60, S-34; airman trainees NS-91, S-19; pentathlon athletes NS-14, S-0) can greatly assist in the overall selection of personnel in preflight, postflight, and in-training programs. Author

N73-21099 Centre de Medecine Aeronautique, Brussels (Belgium)

THE SELECTION AND SURVEILLANCE OF STUDENT PILOTS WITH MOTION SICKNESS IN THE BELGIAN ARMED FORCES [LA SELECTION ET LA SURVEILLANCE DU POINT DE VUE MAL DE L'AIR DES ELEVES-PILOTES DES FORCES ARMEES BELGES]

S. Tribel *In* AGARD Predictability of Motion Sickness in the Selection of Pilots Feb. 1972 3 p In FRENCH (For availability see N73-21092 12-04)

A method of selecting and observing student pilots of the Belgian Air Force is given. Based on this method, 1500 students were admitted to pilot school in 1960 and 1972. Of this number only 7 were eliminated for established cases of motion sickness. Transl. by E.H.W.

N73-21100 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)

TEST RESULTS ABOUT THE EFFECTIVENESS OF METIXENUM APPLIED AGAINST MOTION SICKNESS

Christian Henning *In* AGARD Predictability of Motion Sickness in the Selection of Pilots Feb. 1973 4 p refs (For availability see N73-21092 12-04)

Thirty healthy subjects were tested in a spatial disorientation demonstrator (SDD) in order to compare the effectiveness of Metixenum and Meclocin under double blind comparison test conditions against motion sickness with statistical evaluation. Metixenum reduced all subjective symptoms significantly. Its efficacy was higher than that of Meclocin. Simultaneously recorded objective symptoms (post-rotatory vertigo sensation, heart rate, results of a walking balance test) were not significantly influenced. Author

N73-21101 National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif.

RESPONSES OF BLIND FISH TO GRAVITATIONAL CHANGES AS ACHIEVED IN PARABOLIC FLIGHT

R. J. VonBaumgarten (Mich. Univ., Ann Arbor), G. L. Shillinger, Jr., and G. Baldright (Mich. Univ., Ann Arbor) *In* AGARD Predictability of Motion Sickness in the Selection of Pilots Feb. 1972 4 p refs (For availability see N73-21092 12-04)

Blind fish, during parabolic flight, display a measurable and consistent behavior. The most spectacular new behavioral response is the forward looping of blind fish in or near weightlessness. This response shows no measurable adaptation during the entire period of weightlessness of about 30 sec. During the entrance and exit of weightless parabolas (pushover and pullout) respectively, the fish assumes a forward tilted diving position. Parabolic flight with negative g in the range between 0 g and -1 g causes similar diving responses of the fish with the only difference being that the dive is directed toward the top of the fish tank. When the response to a g value less than 1 g is compared to the response to increased g load on the ground (escape of darting response) an essential difference is seen: higher horizontal acceleration or jerk on the ground causes fish to swim, or even dart against the direction of inertial force; fish during weightless parabolas move into the direction of the inertial or gravitational force. Since the vestibular system of fish is homologous to that of man, the observed behavior of fish in weightless flight could help to better understand human performance and sensations in comparable situations. Author

N73-21102# Advisory Group for Aerospace Research and Development, Paris (France)

THE USE OF MEDICATION AND DRUGS IN FLYING PERSONNEL

Heinz S. Fuchs, ed. Feb. 1973 154 p refs Partly in ENGLISH, partly in FRENCH Proc. of Aerospace Med. Panel Specialist Meeting, Glasgow, 5-6 Sep. 1972 (AGARD-CP-108) Avail: NTIS HC $9.75

Drug effects on flight fitness and the evaluation, detection, and identification of drugs and alcohol in flying personnel are discussed. For individual titles, see N73-21103 through N73-21126

N73-21103 Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT, CONCLUSION, RECOMMENDATIONS
Heinz S Fuchs *In its* The Use of Medication and Drugs in Flying Personnel Feb 1973 13 p refs (For availability see N73-21102 12-04)

Inasmuch as flying effectiveness depends on an optimum degree of psychosomatic fitness, it is axiomatic that the need in a flyer for drugs should raise serious doubts as to his fitness to fly. Increasing age of the flying population is the major contributing factor since there is an increased incidence of disease commonly associated with aging. Improved diagnostic techniques and augmented information about normals and early disease have also had a significant influence upon both the types of problems evaluated and their disposition. The flight surgeon must keep well informed on all drugs, particularly newly accepted ones, so that no medication will be prescribed which might compromise flight safety. Individual susceptibility and hypersensitivity to drugs in general must always be considered. In certain situations drug therapy is warranted to prevent complications and to effect an improvement in long term prognosis. Another problem is acute illness, wherein drug therapy is warranted either to treat primarily the etiology of the disease or more frequently merely to control the symptoms in a self-limited condition. Author

N73-21104 Federal Aviation Administration, Washington, D.C. Office of Aviation Medicine
THE CURRENT STATUS OF DRUG USE IN CIVIL AVIATION PERSONNEL
Peter V Siegel and Stanley R Mohler *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 4 p (For availability see N73-21102 12-04)

Screening data concerning U S civil airmen while being medically certified during the period July 1971 - April 1972 are reported. In the sample studied, two percent of pilots and three percent of ground control personnel had positive urines. The positives included barbiturates, amphetamines, codeine, morphine, and methadone. Author

N73-21105 Royal Air Force Hospital, Ely (England)
MEDICATION AND DRUGS IN AIRCREW
H B Kelly *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 4 p refs (For availability see N73-21102 12-04)

The attitudes adopted by the Royal Air Force and British civil aviation toward medication and drugs taken by their aircrew are discussed and recommendations made. Author

N73-21106 Royal Air Force Inst. of Aviation Medicine, Farnborough (England)
USE OF HYPNOTICS BY AIRCREW 1: OPERATIONAL CONSIDERATIONS AND EXPERIMENTAL STUDIES
A N Nicholson and Catherine M Wright *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 5 p refs (For availability see N73-21102 12-04)

The residual effects of hypnotic drugs for normalizing aircrew sleeping patterns on human nervous function and performance are studied. Delayed matching-to-sample tests on monkeys show that barbiturates do not affect matching-to-stimuli time, but some benzodiazepines increase response times up to 6 hrs after administration. G G

N73-21107 Air Corporations Joint Medical Service (BEA/BOAC), London (England)
ASPECTS OF SLEEP REGULATION IN AIRLINE PILOTS
F S Preston *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 8 p refs (For availability see N73-21102 12-04)

Probably the greatest problem facing long haul civil airlines is the need to ensure that pilots are given adequate time while on a tour of duty to ensure sufficient sleep and so enable them to cope successfully with the ensuing period of work. The problem on long haul routes is greatly compounded by the effect of time zone changes, night flights and changes of a climatic nature which all affect the individual's ability to achieve sleep on arrival. There is definite evidence of cumulative sleep loss on longer trans-meridian routes. As a result, the individual pilot may be tempted to use hypnotics which he can purchase freely over the counter in some parts of the world without medical supervision. In addition, he may use alcohol for its hypnotic action or combined with other hypnotics which may affect not only his fitness to fly on the next day, but have addictive and cumulative effects. The problems are discussed for a long haul airline and some suggestions are made for controlling the situation from both the medical and executive standpoints. Author

N73-21108 Royal Air Force Central Medical Establishment, London (England)
AVMED POLICY ON SLEEP IN AIRCREW
P J OConnor *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb. 1973 2 p (For availability see N73-21102 12-04)

The role of the aviation medical practitioner in relation to aircrew sleep is to instruct the crews in how to anticipate sleep requirements and the best physiological ways of encouraging adequate sleep. Hypnotics should not be used by crews to get sleep as they cause decrement in performance during the subsequent day. Author

N73-21109 Royal Air Force Inst. of Aviation Medicine, Farnborough (England)
USE OF HYPNOTICS BY AIRCREW: ADAPTIVE TRACKING AS A TECHNIQUE FOR THE EVALUATION OF PERFORMANCE DECREMENTS RELATED TO THE FLYING TASK
R C Borland and A N Nicholson *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 5 p refs (For availability see N73-21102 12-04)

The mean performance of 6 subjects tested following the oral administration of secobarbitone at a dose of 3.3 mg/kg of body weight in an adaptive tracking task provides a reasonable approach to evaluating drug after-effects of possible significance to the flying task. Nevertheless, training of personnel and the experimental procedures involved demand considerable effort on the part of subjects and experimenters. Author

N73-21110 Centre d'Essais en Vol, Bretigny-sur-Orge (France).
MODIFICATIONS OF PERFORMANCE UNDER CERTAIN MEDICATIONS: PROPOSED MEASURING METHOD [MODIFICATIONS DE LA PERFORMANCE SOUS L'INFLUENCE DE CERTAINS MEDICAMENTS: A PROPOS D'UNE METHODE DE MESURE]
R. Auffret, R Angiboust, and J. Demange *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 5 p refs In FRENCH (For availability see N73-21102 12-04)

The influence of tranquilizers, hypnotic drugs, and barbiturates on the performance of navigation personnel is investigated. Reaction time, personnel efficiency during complex tasks, and psychological factors were measured. It was determined that some drugs - Fluphenazine, Trifluoperazine, and Prenylamine — do not affect performance, while hypnotic drugs and tranquilizers show some definite performance decrement. Transl. by E.H.W

N73-21111 Army Aeromedical Research Lab., Fort Rucker, Ala
THE EFFECTS OF INH CHEMOPROPHYLAXIS ON AVIATOR PERFORMANCE
Mark A Hofmann *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 8 p refs (For availability see N73-21102 12-04)

A group of tuberculin positive, healthy aviators taking INH prophylactically at dosages of 300 mg daily for one year were maintained on flying status while simultaneously participating in a study to determine the effects of this drug therapy. This investigation measured performance on a number of laboratory tasks to include pursuit tracking, mental multiplication, digit span, reaction time and combinations of the above. No d ments in

performance were observed in this performance as a function of drug treatment. Additionally, these aviators' physical state was assessed by measuring a host of physiological parameters during their year of therapy. There was no evidence of severe drug reactions. It was recommended that aviators be allowed to continue flying duties while taking INH at these dosage levels, but in the interest of safety, a regular program of careful clinical observation and periodic measurements of transaminase levels be conducted. Author

N73-21112 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Bad Godesberg (West Germany). Inst. fuer Flugmedizin.

THE PREDICTION OF FLIGHT SAFETY HAZARDS FROM DRUG INDUCED PERFORMANCE DECREMENTS WITH ALCOHOL AS REFERENCE SUBSTANCE

Karl E. Klein *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb. 1973 12 p refs (For availability see N73-21102 12-04)

A modification of CNS activity resulting in a decrement of performance is the most unwanted side effect of drugs in active flying personnel. A procedure is described where hazard prediction is accomplished with ethanol as reference substance through the following steps: (1) Evaluation of dose-effect-relationship for ethanol with the performance test to be applied in toxicological drug studies, and (2) Examination of drug with the alcohol calibrated test method, estimation of the alcohol intoxication level equipotential in its performance decrement to the drug dose studied, definition of the operational significance of the drug induced performance changes by reference to the intoxication-hazard-relationship established for alcohol, prediction of the critical drug dose through extrapolation. Results with sedative, neuroleptic, tranquilizing and stimulating drugs are demonstrated and the advantage and limitations of the reference procedure discussed. Author

N73-21113 Ohio State Univ., Columbus. Aviation Medicine Research Lab.

ETHYL ALCOHOL AND PILOT PERFORMANCE: MILITARY IMPLICATIONS OF IN-FLIGHT STUDIES

C. E. Billings, R. L. Wick, Jr., R. J. Gerke, and R. C. Chase *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb. 1973 11 p refs (For availability see N73-21102 12-04)

Sixteen instrument-rated civil pilots flew 501 instrument landing system approaches in a light airplane at night under simulated instrument flight conditions while sober and while under the influence of .04, .08 and .12 G% blood ethyl alcohol concentrations. Data included continuous measurement of deviations from localizer and glide path centerline; note was made of all procedural errors. While the highly experienced pilots maintained better tracking performance than the less experienced subjects, particularly at high blood alcohol levels, both groups demonstrated progressive increases in the number and seriousness of procedural errors with each increase in alcohol level. These results indicate that alcohol-induced performance degradation may occur first in secondary tasks rather than in the primary flying task. They also indicate that there is potentially dangerous deterioration in the performance of even highly skilled aviators at blood alcohol levels as low as .04%. Author

N73-21114 Caen Univ. (France). Faculte de Medecine et de Pharmacologie.

THE OPTIMIZATION OF FORM [L'OPTIMISATION DE LA FORME]

Robert N. Lemaire *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb. 1973 3 p In FRENCH (For availability see N73-21102 12-04)

Sports medicine, in relation to the effects of drugs on physical and psychological performance, is discussed. Three points were established for good physical form during competitive activities. They are: (1) maintenance of electrolytic equilibrium, (2) supplementation of normal vitamin levels, and (3) regulation of acid overloads. Transl. by E.H.W.

N73-21115 Mainz Univ. (West Germany). Inst. of Forensic Medicine.

DRUG USE AND PERFORMANCE

J. G. Gostomzyk, P. Parade, and H. Gewecke *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb. 1973 5 p refs (For availability see N73-21102 12-04)

Psychological and physiological effects of acute cannabis intoxication are considered. It is shown that hashish smoking does not affect oxygen consumption in man. However, performance requirements in driving a car under the influence of the drug appear to be felt as stress which demands a response from a psychologically stimulated high energy level. Reduced performance capability manifests itself if actual stress situations are superimposed upon the normal task. It is concluded that hashish impairs the ability to drive safely. G.G.

N73-21116 BioTechnology, Inc., Falls Church, Va.

USE OF SPECTRAL ANALYSIS PROCEDURES FOR THE EVALUATION OF DRUG EFFECTS

James F. Parker, Jr. and Thomas W. Frazier (Walter Reed Army Inst. of Res., Washington, D.C.) *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb. 1973 9 p refs (For availability see N73-21102 12-04)

The use of spectral analysis procedures in the study of drug effects is described in an attempt to develop a more sensitive and meaningful index of performance change. Spectral analysis procedures use time series data in which basic biorhythmicities in performance are identified and studied as the subject is exposed to a stress condition (drug administration). Oscillatory performance profiles are transformed from the time domain to power spectra. These spectra then are examined by means of statistical coherence estimates. Changes in the coherence of these biorhythms provide a measure of the extent to which the organization of a complex performance has been disrupted by the stress condition. Subjects were administered a tranquilizing drug (chlordiazepoxide) under double-blind conditions. A significant loss of coherence was found for the performance of a vigilance task. No change was found in the accompanying physiological measures: heart rate and rectal temperature. These results clearly show a drug induced desynchronization of performance in a human data processing activity. It is concluded that spectral analysis techniques may be of value as one tool in the complete evaluation of drug effects. Author

N73-21117 School of Aerospace Medicine, Brooks AFB, Tex.

DRUG ABUSE DETECTION EFFORTS

George D. Lathrop, Harold L. Kaplan, and Jack E. Wallace *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb. 1973 4 p refs (For availability see N73-21102 12-04)

Operational efforts to detect drug abuse by mass-screening urinalysis are summarized. Particular emphasis is given to the current analytical methods used to detect opiates, barbiturates, and amphetamines. Advantages and disadvantages of available methodology are presented to provide rationale guidelines for establishing an accurate and forensically reliable toxicology laboratory. Methods of thin layer chromatography and gas-liquid chromatography offer unparalled detection accuracy for drugs of abuse, as well as a capability to analyze therapeutic levels of certain psychotropic drugs (tranquilizers, antihistamines) of specific concern in flying populations. Tandem research efforts to improve current methodology for the diethylamide of lysergic acid (LSD), tetrahydrocannabinols (THC), and methadone, and to develop new tests based on individual enzymatic changes, are briefly presented. Author

N73-21118 Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

USE OF HYPNOTICS BY AIRCREW: CONSIDERATIONS OF METABOLISM AND EXCRETION

J. M. Clifford and J. H. Cookson *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb. 1973 6 p refs (For availability see N73-21102 12-04)

The metabolism of secobarbitone, heptabarbitone and the

nonbarbiturate hypnotic methaqualone have been studied in man using the technique of gas liquid chromatography. A polarographic technique for plasma levels of nitrazepam has also been investigated. Author

N73-21119 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).
THE IMPACT OF DIURNAL RHYTHM ON DRUG DOSING AND DRUG EVALUATION
H. W. Kirchhoff *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb. 1973 4 p (For availability see N73-21102 12-04)

The well known fact that the functional behavior of the human organism is subjected to a rhythmically occurring daily process is still being disregarded in clinical practice and pharmacology. Drug dosing, instead of sticking to the stereotyped pattern of 3 x 1 tablet/day, requires full consideration of the diurnal variations which occur in the human body involving mainly cardiovascular parameters. Drug evaluation, on the other hand, should also include careful studies in diurnal rhythm in order to obtain precise data on the duration and onset of drug action as well as on specific influence emerging in the course of the day, all the more since any approach of this kind will contribute to the elimination of untoward side effects and other hazardous influences which may be attributed to a drug. Author

N73-21120 Hopital d'Instruction des Armees, Versailles (France).
ANTIDIABETIC MEDICATIONS AND NAVIGATION PERSONNEL [MEDICAMENTS ANTIDIABETIQUES ET PERSONNEL NAVIGANT]
Roger Pannier and Gerard Leguay *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 6 p In FRENCH (For availability see N73-21102 12-04)

The use of antidiabetic drugs and the fitness of such people as navigation personnel are examined. It was determined that the insulin-dependent sugar diabetic is unfit for such jobs because he is subject to keto-acidosic accidents, hypoglycemia, and regimented diets unsuited for his job. In non-insulin dependent diabetics who are maintained by oral drugs, it was determined that those who use sulphenylureas are also unsuited for flying duties since this drug sometimes causes hypoglycemia. Diabetics taking biguanide, it was determined, may under exceptional circumstances become or continue to be flying personnel. These drugs do not produce hypoglycemia as do the other medicants studied. Transl by E H W

N73-21121 Royal Air Force Hospital, Ely (England).
OCULAR SIDE EFFECTS OF DRUGS IN AVIATION MEDICINE
G. W. T. Smith *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 2 p (For availability see N73-21102 12-04)

Many drugs which may be prescribed for aircrew or used by aircrew in self medication have known reported ocular side effects which can affect visual performance. Reviewed are some of the main groups of these drugs, drawing attention to these side effects. Author

N73-21122 Advisory Group for Aerospace Research and Development, Paris (France).
OPHTALMOLOGIC SURVEILLANCE OF ABSORBED ANTIMALARIA DRUGS IN SYSTEMS OF NAVIGATION PERSONNEL [SURVEILLANCE OPHTALMOLOGIQUE DU PERSONNEL NAVIGANT ABSORBANT DES ANTIPALUDEENS DE SYNTHESE]
J. P. Chevaleraud (CPEMPN, Paris) *In its* The Use of Medication and Drugs in Flying Personnel Feb 1973 5 p In FRENCH (For availability see N73-21102 12-04)

Observations of synthetic antimalarials, through opthalmological methods, in the systems of navigation personnel were made. Risks to test subjects and toxic side effects are discussed. Transl by E H W

N73-21123 Flugzeugfuehrerschule, Klein Heidorn (West Germany).
TRANQUILIZERS AND AVIATION
Heinrich Schulte-Wintrop *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 4 p refs (For availability see N73-21102 12-04)

The use of tranquilizers during periods of flying duty is still infrequent and no direct effects on flight safety have so far been positively observed; there is, however, a danger of such effects in case of excess dosage and use of ataractics such as diazepam. A potentiating effect by alcohol has been described in some cases, but the influence of alcohol alone appears to be the crucial factor in these cases. It is shown that ataractics like chlordiazepoxide fail to alleviate stress reactions in student pilots, but that the application of certain tranquilizers in treating different types of kinetosis seems promising. The prescription of tranquilizers should be avoided until the effects these medicaments have in combination with the varied strains encountered in aviation have been fully surveyed. Author

N73-21124 Fighter Bomber Wing (31st), Kerpen/Erft (West Germany).
USE OF MEDICATION AND DRUGS, ESPECIALLY ALCOHOL, BY FLYING PERSONNEL
Hugo Hembach *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 5 p refs (For availability see N73-21102 12-04)

Alcohol is the most common and most dangerous drug used by pilots. Three simple methods are described by which the blood alcohol can be determined: (1) By means of two tables pilots are able to determine the approximate level of blood alcohol concentration after the consumption of a known amount of alcoholic beverage over a given period of time, (2) the detection of the gross post-rotational nystagmus which is found whenever the central nervous system has been affected by alcohol, and (3) a semi-quantitative method of breath analysis for alcohol detection in the blood. These three methods make it possible to single out pilots who have alcohol in their blood and to prevent them from flying. Author

N73-21125 Centre d'Essais en Vol, Bretigny-sur-Orge (France).
EFFECT OF ALTITUDE ON CEREBRAL BLOOD FLOW PATTERNS IN THE SMOKER AND NONSMOKER [ACTION DE L'ALTITUDE, CHEZ LE FUMEUR ET LE NON FUMEUR SUR LES VARIATIONS DU DEBIT SANGUIN CEREBRAL]
J. Demange and R. Auffret *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 5 p refs In FRENCH (For availability see N73-21102 12-04)

Variations in the cerebral blood circulation of smokers and nonsmokers as a function of altitude are measured rheographically. Also measured were the effects of vasometric drugs, altitude tolerance, chronic hypoxia, and performance as influence by blood flow. Transl by E H W

N73-21126 Institute of Pharmacology, Oslo (Norway).
COMPARISON OF MENTAL AND PSYCHOMOTOR EFFECTS OF DIAZEPAM AND ETHANOL
J. F. W. Haffner et al *In* AGARD The Use of Medication and Drugs in Flying Personnel Feb 1973 10 p refs (For availability see N73-21102 12-04)

Whether and to what extent a single, large therapeutic dose of diazepam affects mental and psychomotor functions in man was determined. The effects of diazepam in dosages of 10 and 20 mg/70 kg body weight have been compared with those of alcohol in amounts which were designed to produce blood levels of approximately 0.1%. Serum concentrations of diazepam were estimated in order to see whether it was possible to establish a correlation between dosages, serum concentrations and effects. It was shown that diazepam has a negative influence on the results of a series of tests with relevance to performance. In none of the tests was there any improvement in mean score after diazepam compared with placebo. However, a comparison of the test results reveals some differences between the effects of alcohol and diazepam. Author

N73-23057# Advisory Group for Aerospace Research and Development, Paris (France)
CURRENT STATUS IN AEROSPACE MEDICINE
Walton L Jones, ed (NASA, Washington, D C) Feb 1973 77 p refs Presented at Aerospace Med Panel Specialist Meeting, Glasgow, Scotland, 7-8 Sep 1972
(AGARD-CP-110) Avail NTIS HC $6.00

Proceedings from an aerospace medicine conference are presented, emphasizing human tolerances to various stress factors incurred during flight. The diseases, syringomyelia and hepatitis, are considered in terms of their effect on the flying fitness of personnel. Compound breeding of Rhesus monkeys is included. For individual titles, see N73-23058 through N73-23068

N73-23058* National Aeronautics and Space Administration, Washington, D C
RECENT NASA AEROSPACE MEDICINE TECHNOLOGY DEVELOPMENTS
Walton L Jones *In* AGARD Current Status in Aerospace Med Feb 1973 8 p refs (For availability see N73-23057 14-04)
CSCL 06E

Areas of life science are being studied to obtain baseline data, strategies, and technology to permit life research in the space environment. The reactions of the cardiovascular system to prolonged weightlessness are also being investigated. Particle deposition in the human lung, independent respiratory support system, food technology, and remotely controlled manipulators are mentioned briefly J A M

N73-23059 Naval Aerospace Medical Research Lab., New Orleans, La
NON-FATAL EJECTION VERTEBRAL FRACTURE AND ITS PREVENTION
Channing L. Ewing *In* AGARD Current Status in Aerospace Med Feb 1973 8 p refs (For availability see N73-23057 14-04)

Several studies of the nature and extent of the problem were made. Jones et al showed that 21% of 165 U S Navy aviators suffered vertebral fracture using a gun-type ejection seat over a 4 1/4 year period 1958-1963 (2) Of these, six were retired on disability and one additional died. Fryer found a 19% incidence in 220 R A F ejection using a similar seat. (3) Hirsch found a 25% incidence in 55 Swedish Air Force ejections using a different seat (4) More recently, Shannon found that in the U S A F during CY 1967 and 1968, there were 390 noncombat ejections with 116 persons suffering major nonfatal injury (5) Forty-one of the major injuries were fractures due to ejection force, and 97% of these were vertebral fractures. In the combat ejections, 89% of major injuries due to ejection force were vertebral fractures, and 80% of all vertebral fractures suffered were due to ejection force. In all, 31% of noncombat and 25% of combat major injuries on ejection were nonfatal ejection vertebral fractures. In both cases the ejection vertebral fractures were the largest single category of major injury Author

N73-23060 Hellenic Air Force General Hospital, Athens (Greece)
MANAGEMENT OF ASYMPTOMATIC CARRIERS OF HEPATITIS-ASSOCIATED-ANTIGEN (HAA) IN HELLENIC AIR FORCE PERSONNEL
H G Vissoulis and C E Giannopoulos *In* AGARD Current Status in Aerospace Med Feb 1973 4 p refs (For availability see N73-23057 14-04)

A large-scale investigation among Hellenic Air Force personnel was instituted in Jan 1971 aiming at detecting the asymptomatic HAA carriers and recommending means of prevention, medical disposition and/or elimination from flying and certain specialties. This systematic screening is justified by a high correlation of positive HAA and cases of acute viral hepatitis. A disquieting incidence of 5.2% of asymptomatic HAA carriers was demonstrated Author

N73-23061 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
SYRINGOMYELIA AND FLYING FITNESS
Guenter Apel *In* AGARD Current Status in Aerospace Med Feb 1973 3 p refs (For availability see N73-23057 14-04)

The extent to which the existing syringomyelia had contribution to fatal accidents and the question of specific flying conditions being conducive to an exacerbation of syringomyelia are discussed. Histological examinations of organs of pilots involved in fatal accidents have often revealed diseases, in particular those involving the heart, which may have limited flying fitness Author

N73-23062 Johann-Wolfgang-Goethe-Universitat, Frankfurt am Main (West Germany) Arbeitsgruppe fuer Biophysikalische Weltraumforschung
THE BIOSTACK EXPERIMENT ON APOLLO 16
H Buecker *In* AGARD Current Status in Aerospace Med Feb 1973 6 p refs (For availability see N73-23057 14-04)

The objective of the BIOSTACK experiment, flown onboard Apollo 16, is to study the combined action of individual heavy high energy loss nuclei of cosmic radiation and space flight factors on biological systems in resting state. The results will give information on the mechanism of heavy particles on biological matter. The BIOSTACK experimental package contains a series of monolayers of selected biological objects (Bacillus subtilis spores, Arabidopsis thaliana seeds, Vicia faba radiculae, Artemia salina eggs) with each layer sandwiched between several different physical track detectors (nuclear emulsions, cellulose nitrate, polycarbonate). Individual local evaluation methods were developed which identify each biological effective particle and correlate the individual hitting particle with the produced biological effect. A variety of biological effects due to a single penetrating particle is being analyzed: influence on cellular and tissue development, nuclear damages, and mutation induction. Author

N73-23063* Flugwissenschaftliche Forschungsanstalt, Munich (West Germany) Yerkes Primate Research Center
BREEDING MONKEYS FOR BIOMEDICAL RESEARCH
Geoffrey H Bourne, M Nelly GolarzdeBourne, and Michale E Keeling *In* AGARD Current Status in Aerospace Med Feb 1973 6 p refs (For availability see N73-23057 14-04)
(NASA Order R-10-009-013, Grant RR-00165)
CSCL 06C

Captive bred rhesus monkeys show much less pathology than wild born animals. The monkeys may be bred in cages or in an outdoor compound. Cage bred animals are not psychologically normal which makes them unsuited for some types of space related research. Compound breeding provides contact between mother and infant and an opportunity for the infants to play with their peers which are important requirements to help maintain their behavioral integrity. Offspring harvested after a year in the compound appear behaviorally normal and show little histopathology. Compound breeding is also an economical method for the rapid production of young animals. The colony can double its size about every two and a half years. Author

N73-23064 Royal Air Force Inst of Aviation Medicine, Farnborough (England)
HYBRID COMPUTING: A TECHNIQUE FOR THE IMMEDIATE ANALYSIS OF PHYSIOLOGICAL DATA
G H Byford *In* AGARD Current Status in Aerospace Med Feb 1973 4 p refs (For availability see N73-23057 14-04)

The solution must include a means for rejecting that part of the data considered to be of little importance, a technique for establishing the probable difference between two possibly similar recordings, or the probable similarity between two apparently different recordings, and the speedy processing of data, preferably but not necessarily carried out during the experiment. Much can be done with simple and easily understood statistics, a small hybrid computer and the allocation of a little thought to the problem as a whole rather than to its isolated part. These processes are illustrated by considering the real-time analysis of a multichannel electrophysiological recording, using uncomplicated mathematics and the parallel-serial hybrid computing installation Author

N73-23065 School of Aerospace Medicine, Brooks AFB, Tex Applied Physiology Branch
AEROMEDICAL EVALUATION OF TH PHASED-DILUTION CONCEPT FOR OXYGEN BREATHIN 'STEMS

Robert W Krutz, Jr, William J Sears, Kenneth G Gould, Jr, and Richard W Bancroft *In* AGARD Current Status in Aerospace Med Feb 1973 7 p refs (For availability see N73-23057 14-04)

This series of studies was designed to compare the relative effectiveness of phased-dilution with current demand-diluter oxygen delivery systems in artificially ventilated dogs and in seated, quietly breathing humans. The arterial oxygen tension approximately doubled in the canine model with the phased-dilution oxygen delivery when compared with comparable quantities of premixed oxygen at ground level and at simulated altitudes of 10,000 and 18,000 feet in a decompression chamber. Arterial oxygen tensions in humans breathing in a random fashion were higher with the phased-dilution oxygen delivery system than with comparable quantities of premixed oxygen. Human arterial oxygen tensions measured with the phased-dilution technique at ground level and in a chamber at subatmospheric pressures equivalent to altitudes of 10,000 and 18,000 feet were less than predicted from the canine work. It appears that this more limited effectiveness is closely related to a respiratory dead space effect and is influenced by frequency and depth of breathing with a fixed bolus Author

N73-23066 Naval Aerospace Medical Research Lab, New Orleans, La

SPECIALIZED ANTHROPOMETRY REQUIREMENTS FOR PROTECTIVE-EQUIPMENT EVALUATION

Daniel J Thomas *In* AGARD Current Status in Aerospace Med Feb 1973 8 p refs (For availability see N73-23057 14-04)

Anthropometry was considered from the point of view of its application to problems of protective-equipment evaluation, human impact-acceleration experiments, and flying personnel populations. The difficulties of supplying data for all three areas of endeavor are discussed. A three-dimensional anatomically referenced basis for recording anthropometric data is offered as an adequate approach. Coordinate systems for the head and the first thoracic vertebral body are described Author

N73-23067 Office of the Air Force Surgeon General, Washington, D C

HUMAN EXPOSURE CRITERIA TO LASER ENERGY

Donald I Carter, William E Mabson, and James F Culver *In* AGARD Current Status in Aerospace Med Feb 1973 5 p ref (For availability see N73-23057 14-04)

The United States Air Force is adapting laser technology to many combat and combat support uses. Some of these uses include distance measuring to assist in aiming airborne guns in the AC-130 gunships, boresighting guns on fighter aircraft, and target marking for accurate aerial bombing. The number of different lasers and their uses are increasing. Since these high energy monochromatic light beams can produce biological damage, safe exposure criteria are needed to assist in developing safe exposure distances, protective devices, and medical surveillance programs Author

N73-23068 Centro di Studi e Ricerche di Medicina Aeronautica e Spaziale, Rome (Italy)

STUDY ON SOME AIR FORCE OPERATIONAL ACTIVITIES IN ITALY, WITH REFERENCE TO THERMAL CONDITIONS AND THEIR EFFECTS ON ACCELERATION TOLERANCE AND PSYCHOMOTOR PERFORMANCE

Paolo Rota *In* AGARD Current Status in Aerospace Med Feb 1973 10 p refs (For availability see N73-23057 14-04)

Climate in Italy, in summer period presents such characteristics that, in Air Force operational activities, performance of AF personnel can be affected. Because of this a series of researches was carried out in this field. After a brief survey on main features of Italian climate and summer climatic conditions in some AF bases, the results are reported on microclimatic data recorded in the interior of the cockpit and inside motor vehicles cabins while parking in summer daylight period. Physiological importance of these data, and the effects on working efficiency are discussed and evaluated by means of some heat stress indexes. Results of experimental parallel researches are also reported to assess the effects on acceleration tolerance and psychomotor performance, of situations simulating scramble take off Author

N74-12748# Advisory Group for Aerospace Research and Development, Paris (France)

SPATIAL DISORIENTATION IN FLIGHT: A HANDBOOK FOR AIRCREW

A. J. Benson (RAF Inst. of Aviation Med.) and E Burchard (German AF Med Corps) Sep 1973 43 p refs (AGARD-AG-170) Avail NTIS HC $4.25

It has been known for many years that aircrews/suffer from false sensations and perceptions of aircraft motion and that these illusions may hazard the safety of the aircraft and its occupants. This handbook considers the various manifestations of spatial disorientation, their causes and consequences for the benefits of aircrews and their medical attendants Author

N74-13784# Advisory Group for Aerospace Research and Development, Paris (France)

PATHOPHYSIOLOGICAL CONDITIONS COMPATIBLE WITH FLYING

Heinz S Fuchs ed (German Fed Armed Forces, Bonn) Oct 1973 152 p refs In ENGLISH and FRENCH Presented at AGARD Aerospace Med Panel Specialist Meeting, Pensacola, Fla, 16-17 May 1973 (AGARD-CP-129) Avail NTIS HC $9.75

Medical selection and maintenance procedures for aircrews are reported. The effects of ageing, flight stress, clinical and psychophysiological pathological factors on pilot flight fitness are considered. For individual titles, see N74-13785 through N74-13806

N74-13785 German Federal Armed Forces, Bonn

TECHNICAL EVALUATION REPORT, CONCLUSION AND RECOMMENDATIONS

Heinz S Fuchs *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 10 p (For availability see N74-13784 05-04)

In the past physical standards have been overly conservative because it was necessary to base aeromedical criteria on medical concepts derived from experience with diseased states in hospital patients. Increasing experience with aircrew populations based upon specific studies to disclose the relationships between the pathophysiology of early disease and the psychophysiological requirements of flight, allows a more subtilized interpretation of diagnostic and clinical findings and gives now a wider and safer prognostication. Therefore, it is believed that there is a justification to change these standards - based upon systematic and scientific reevaluation, taking advantage of newly developed knowledge and research techniques. Because of the unique nature of the ageing aircrew population it is frequently necessary to accomplish this research ... upon the flyers themselves, rather than to extrapolate from general medical research Author

N74-13786 Naval Aerospace Medical Research Lab, Pensacola, Fla

THE THOUSAND AVIATORS: AGING AND THE BLOOD PRESSURE

Robert E Mitchell *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 3 p (For availability see N74-13784 05-04)

Blood pressure patterns are discussed for the members of a research group over a 32 year period and the implications of the patterns. In contrast to what was previously thought to be the case, namely that blood pressure levels not rise with increasing age, the latest survey indicates that there are many and important exceptions to this generality after 45 years of age. Since this is the period when most naval aviators enter the administrative phase of their careers, the finding has less significance than if it occurred at an earlier age but has greater operational significance in the case of commercial airline pilots inasmuch as these men

continue to fly at age 60 It would appear that this late onset ...ed blood pressure justifies the more liberal standards for ...ssion to flight training At the same time personnel in an active flight status can be allowed to continue active flying if no complications are noted and treatment is not indicated
Author

N74-13787 Naval Aerospace Medical Research Lab, Pensacola, Fla
ELEVATED BLOOD PRESSURE IN AIRCREW
D R Stoop, K C Stanton and D D Brown *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 5 p (For availability see N74-13784 05-04)

The evaluation, management, and disposition of the aircrew with elevated blood pressure are frequently difficult problems. Analysis of evaluations reveals an obvious reluctance on the part of the physician to establish a diagnosis of hypertension and a tendency to avoid drug therapy in spite of accepted evidence that early treatment reduces morbidity The implications and potential problems in this approach have been discussed, and current practices and policies regarding the aircrew with hypertension have been presented and defended Author

N74-13788 School of Aerospace Medicine Brooks AFB, Tex Internal Medicine Branch
RETURNING AIRMEN WITH ABNORMAL EXERCISE TESTS AND NORMAL CORONARY ANGIOGRAMS TO FLYING STATUS
Victor F Froelicher, Frank G Yanowitz, A J Thompson, and Malcolm C Lancaster *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 7 p refs (For availability see N74-13784 05-04)

Individuals with ST segment changes during and/or after exercise are considered to have an increased risk of developing the manifestations of CAD (Coronary Artery Disease) However, it is also known that both the double Master's test and maximal treadmill testing yield false positive and negative results reactive to CAD The results of coronary angiography are presented in 63 asymptomatic aircrewmen with resting repolarization abnormalities and exercise testing responses suggestive of coronary artery disease Fifty-four per cent had angiographic coronary artery disease and many had high risk lesions Forty-six per cent had no angiographic lesions and were recommended for return to flying duties The findings in this study, the lack of significant complications, the concern for public safety, and the economics of maintaining a flying force justify the continued use of elective coronary angiography in selected asymptomatic aircrewmen
Author

N74-13789 School of Aerospace Medicine, Brooks AFB, Tex Applied Physiology Branch
MYOCARDIAL AND CEREBRAL FUNCTION DURING EXPOSURE TO CARBON MONOXIDE
Howard H Erickson and Milton J Hernandez-Perez *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 6 p refs (For availability see N74-13784 05-04)

Aircrew members exposed to carbon monoxide may sustain an increase in coronary blood flow and a reduction in oxygen delivery to the heart and brain These factors may result in a decrement in man's performance in strategic and tactical weapon systems in an enemy defense environment Since many of the stresses -- such as physical exertion, altitude hypoxia and acceleration -- are cumulative, carbon monoxide may affect the heart and cardiovascular system of man during operational flying by decreasing still further the oxygen supply and reserve in the heart and brain Author

N74-13790 Hopital d'Instruction des Armees, Versailles (France)
CARDIAC VALVULOPATHIES AND FLIGHT TOLERENCE [CARDIOPATHIES VALVULAIRES ET TOLERANCE AU VOL]
G Leguay *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 12 p refs In FRENCH (For availability see N74-13784 05-04)

Due to exceptional circumstances 8 pilots suffering from aortic insufficiency, aortic stenosis, and mitralis stenosis have been on flying status, aeromedically monitored up to 15 and 20 years The cardiac valvulopathies raise a twofold problem they may potentially endanger flight safety by leading to a sudden cardiac syncope and they can be aggravated by flying, particularly by acceleration forces Flight safety, however, has never been threatened by these aircrew in the light of experience over several years The tolerance of flying pilots suffering from moderate aortic insufficiency seems satisfactory, in particular in fighter pilots exposed to high g-loads Author

N74-13791 Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)
VALUE OF CARDIAC MECHANOGRAMS IN EVALUATING FLYING PERSONNEL [INTERET DES MECANOGRAMMES CARDIAQUES DANS L'EXPERTISE DU PERSONNEL NAVIGANT]
R Carre, C Nogues, and B Raviart *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 14 p refs In FRENCH (For availability see N74-13784 05-04)

Cardiac mechanograms provide useful information in the medical evaluation of aircrew and are obtained fast and easily by a noninvasive technique The cardiogram itself provides an estimate of the elasticity of the arterial wall, and in that way gives criteria for atherosclerosis The combined use of chronocardiographic methods (EGG, cardiogram) provides an opportunity of validating the contractibility of the cardiac muscle These methods are important in the cardiologic survey of aircrew, both to detect atherosclerosis and monitor arterial hypertension
Author

N74-13792 Hopital d'Instruction des Armees, Versailles (France) Service de Medecine Aeronautique
ASTHMA IN MILITARY FLYING PERSONNEL [L'ASTHME DANS LE PERSONNEL NAVIGANT MILITAIRE]
R Pannier *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 8 p refs In FRENCH (For availability see N74-13784 05-04)

Detection of bronchial asthma is based mainly on actually observed acute episodes That is the reason why applicants for flight training will be accepted unless they are subjected to an acetylcholin test It is well known that patients with bronchial asthma benefit from flying However, because of its serious consequences if it occurrs in flight, bronchial asthma is considered to jeopardize flight safety It is important to realize that treatments have to be adapted to the aircrew tasks since some medications may be contraindicated for flying activities in view of their secondary effects Therefore, applicants for flying duties suffering from bronchial asthma must be rejected, aircrew who develop bronchial asthma during an established career might be considered for a waiver on an individual basis, but as a rule they will not be authorized for primary control of aircraft Author

N74-13793 Hopital d'Instruction des Armees, Versailles (France)
IDIOPATHIC SPONTANEOUS PNEUMOTHORAX IN FLYING PERSONNEL [LE PNEUMOTHORAX SPONTANE IDIOPATHIQUE DANS LE PERSONNEL NAVIGANT]
Roger Pannier *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 6 p In FRENCH (For availability see N74-13784 05-04)

Rupture of subpleural blebs is considered the most frequent cause of idiopathic spontaneous pneumothorax Idiopathic spontaneous pneumothorax can occur in flight in the course of rapid decompression, by ascent to altitude both in flight and in an altitude chamber when trapped air within these blebs expands and ruptures the thin pleural layer, by an hydrostatic hemodynamic effect, or incidentally without any concomitant exertion or any physical stress Applicants for flight training reporting one episode of idiopathic spontaneous pneumothorax must be rejected, aircrew on active duty and with an established flying career must be grounded unless they have undergone successful pulmonary surgery Ten out of thirteen aircrew who suffered from idiopathic spontaneous pneumothorax were kept on flying status after successful pulmonary surgery The time of grounding ranged from 3 to 14 months Author

N74-13794 Centre d'Essais en Vol, Bretigny-sur-Orge (France)
AIRCREW'S FITNESS FOR FLYING DUTIES AFTER VERTEBRAL FRACTURES AND SPINAL SURGERY [APTITUDE AU VOL DU PERSONNEL NAVIGANT APRES FRACTURES DU RACHIS ET INTERVENTIONS CHIRURGICALES SUR LA COLONNE VERTEBRALE]
Roland-Paul Delahaye (Service de Sante pour l'Armee de l'Air, Paris), Robert Auffret, Jacques Mine (Hopital Begin, Saint-Mande), and Pierre-Jean Metges (Hopital Begin, Saint-Mande) *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 7 p refs In FRENCH (For availability see N74-13784 05-04)

Some features of flying such as vibration and accelerations, may sensitize the spine, ejection seat bail-out and/or crash can result in more or less deleterious spine injuries and fractures. After every accident, spinal disorders, or spinal surgery aircrew must be reexamined for flying fitness. After fractures it is of the utmost importance to determine the degree of spinal stability or instability, such as after spinal disorders e.g. osteoarthrosis or arthrosis, or surgery (laminectomy), or surgery for disc hernias or spondylolisthesis. Special emphasis has been given to the evaluation of aircrew with repeated vertebral traumas on damaged spines and fractures after surgery for spinal conditions. Author

N74-13795 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
THE RISK OF MINOR SPINAL ABNORMALITIES IN AIRCREWS: EVALUATION OF EJECTION CASES
A Beck *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 4 p refs (For availability see N74-13784 05-04)

An attempt has been made to determine pre-existing spinal abnormalities in aircrew which may have had a detrimental effect on the traumatic events, retrospectively, i.e. after fracture of the vertibral body had occured. The collection of these findings was compared with cases of ejection seat bailouts without injuries or fractures in order to recognize morphological alterations which may possible be conducive to fracture. Author

N74-13796 Advisory Group for Aerospace Research and Development, Paris (France)
AERONAUTICAL REHABILITATION OF FLYING PERSONNEL SUFFERING FROM ACUTE PSYCHIATRIC DISTURBANCES [LA REHABILITATION AERONAUTIQUE DES MEMBRES DU PERSONNEL NAVIGANT AYANT PRESENTE DES TROUBLES PSYCHIATRIQUES AIGUS]
R Gelly and J C Hadni *In its* Pathophysiol Conditions Compatible with Flying Oct 1973 9 p In FRENCH (For availability see N74-13784 05-04)

Acute psychiatric symptoms combined with behavioral anomalies are normally aeromedical reasons for rejection both from flying and from regular military service. Based on an extensive case report survey, it can be demonstrated fairly clearly that such decisions are not always justified. Each case must be considered from an individual viewpoint since in many cases psychiatric symptoms and behavioral anomalies cannot be diagnosed with absolute certainty. In particular some obviously serious crises merely reflect individual difficulties in the course of adaptation. Any decision must therefore be based on a diagnosis of the personality structure and personality tests must be considered a major element of psychopathological diagnosis. Psychotherapy can bring to a satisfactory solution some psychiatric syndromes which have been in the past considered irreversible. However psychotherapy in order to be successful must be associated with concurrent actions both in the professional environment and in further flying training, etc. Under these conditions the rehabilitation for flying duties of aircrew who had acute psychiatric troubles, possible. Author

N74-13797 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
IMPORTANCE OF THE 4-5 c/sec RHYTHM IN THE EEG TO DETERMINE MILITARY FLYING FITNESS
H Oberholz *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 3 p refs (For availability see N74-13784 05-04)

The 4-5 c/sec rhythm is probably a genetically determined variant of the normal EEG which may easily be misinterpreted as a fairly serious general alteration of the EEG. In order to differentiate between similar EEG patterns, the characteristics of this EEG-variant and the special mode of EEG registration were discussed and appropriate EEG's demonstrated. From the literature, the results of family examinations including possible causes of these EEG-variants were presented. Psychological peculiarities in persons showing this EEG variant were emphasized and criteria for the assessment of military flying fitness and preventive measures were proposed. Cases found were analyzed and the procedures applied to variant carriers presented. Author

N74-13798 Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)
OPHTHALMOLOGICAL SUPERVISION OF DIABETIC FLYING PERSONNEL [SURVEILLANCE OPHTALMOLOGIQUE DU PERSONNEL NAVIGANT DIABETIQUE]
J P Chevaleraud and G Perdriel *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 5 p In FRENCH (For availability see N74-13784 05-04)

With reference to diabetes mellitus, the ophthalmologist's role can be twofold, through his special examinations he can detect this disorder very early and he can monitor its different forms, its several steps of evolution, and its implications for flying fitness. Based on broad clinically and functionally oriented knowledge and electrophysiological experience, some interesting proposals for the evaluation of aircrews who suffer from different forms of diabetes mellitus are reported. Author

N74-13799 School of Aerospace Medicine, Brooks AFB, Tex Aerospace Medical Div
MANAGEMENT OF GLAUCOMA IN AN AGEING FLYING POPULATION
Thomas J Tredici, James L Mims, III and James F Culver *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 3 p refs (For availability see N74-13784 05-04)

Ageing has definite and certain predictable effects on the visual apparatus. Loss of accommodation with age hampers important visual tasks in the cockpit. Disease processes that are common in any population will eventually also affect the flyer. The occurrence of narrow angle glaucoma in the flying population is so small that it is insignificant, however with relative maturation of a flying force a 2 to 3 percent figure does become significant. Glaucoma strikes a flyer after a great deal of time and money have been expended in his training and when his experience could be utilized to the maximum. Medical grounding of a significant number of experienced flyers can be considered a loss. Many flyers with increased intraocular pressure have been retained on flying status by a rationale of diagnosis and treatment. The visual effects of drugs utilized in the treatment of glaucoma have been evaluated. Presently only intraocular tension lowering drugs that do not effect visual function are being used. Author

N74-13800 Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France)
CURRENT ASPECTS OF COCHLEAR FUNCTION APPLIED TO FLYING PERSONNEL [ASPECT ACTUEL DE LA FONCTION COCHLEAIRE CHEZ LE PERSONNEL NAVIGANT]
P Blanc and J Bastien (DCSSA, Paris) *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 3 p In FRENCH (For availability see N74-13784 05-04)

This 9-years survey is based upon 6,024 audiograms of flying personnel who have been rated for at least two years. The results of this investigation can be summarized as follows: (1) Any barotrauma on the middle ear may be neglected; an air passenger who has had stapedectomy for otosclerosis may travel by air without any risk. (2) occupational deafness was not found in flying personnel under investigation. (3) hearing discrimination deficits were found in some individuals since the aviation operational environment stresses aircrew by its considerable noise levels, and (4) 12 aircrew with intact ear drums were found to be suffering from moderate conduction deafness and presenting the classic otosclerotic syndrome. Two of them underwent cochlear

surgery and have flown to date 1 000 flying hrs each. The audiometric results produced by surgery remained excellent.
Author

N74-13801 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
PURE TONE HEARING LOSSES IN PILOTS OF VARIOUS AIRCRAFT, AGE AND FLYING TIME AND ITS SIGNIFICANCE FOR INFLIGHT SPEECH COMMUNICATION
G H Froehlich *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 4 p (For availability see N74-13784 05-04)
The punch cards of 2000 pilots investigated in 1971 have been separated into 4 groups of flying time respectively age, subdivided into pilots of jet aircraft, piston engined aircraft and helicopters. High tone hearing losses were increasing with age and flying time and in helicopter pilots more rapidly than in pilots of the other types of aircraft. A number of pilot's speech audiograms have been investigated. The intelligibility scores of hearing losses above 3000 Hz were excellent and there are no problems with inflight speech communications. Hearing losses above 2000 Hz resulted in intelligibility scores of 72% at low and 85% at medium speech levels. Less than 10% of the pilots above 45 years of age had hearing losses above 1500 Hz. At medium speech levels they obtained only a score of 70%. 100% are frequently not reached even with high speech levels. Together with the masking effect of inflight cabin noise, voice communication might be endangered, especially if the attenuation characteristics of headsets and flying helmets are poor. In these cases, the use of properly fitting headgear is especially important to insure a favorable noise to speech ratio.
Author

N74-13802 Hopital d'Instruction des Armees, Versailles (France)
PROTEINURIAS IN FLYING PERSONNEL [PROTEINURIES ET PERSONNEL NAVIGANT]
G Leguay *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 12 p In FRENCH (For availability see N74-13784 05-04)
Proteinurias have been found much more frequently among air transport aircrew than in fighter pilots. More than 50% of all cases have been observed in aircrew between 20 and 25 years of age which is obviously caused by the age dependant incidence of the orthostatic proteinuria. Chronic proteinurias are in most instances caused by chronic glomerulopathies. If this condition is clinically stabilized, it may be considered compatible with flying. Clearance impairment, however, necessitates a special diet, and the existence of a marked hypertension as well as the incompatibility with vaccinations indicates grounding of these aircrew. To verify the interaction of proteinurias and flying, several individuals were exposed to acceleration forces on the human centrifuge. No significant changes of proteinuria were observed during or after the centrifuge rides. However, barometric stresses which occur when flying at different altitudes may be considered dangerous since these barometric pressure differences can exacerbate infectious lesions in ENT areas.
Author

N74-13803 School of Aerospace Medicine, Brooks AFB, Tex
THE OCCURRENCE OF HYPERLIPIDEMIA IN FLYING AND NONFLYING SUBJECTS OF THE USAFSAM CARDIOVASCULAR DISEASE STUDY
Dale A Clark, Kenneth A Narahara, and Margaret F Allen *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 6 p refs (For availability see N74-13784 05-04)
The subjects of a cardiovascular disease study were separated into flying and non-flying groups, and the occurrence of elevated lipid levels in these groups was tabulated. The question of interest was whether the stresses of flight elevate serum cholesterol and predispose pilots to the development of atherosclerotic heart disease. None of the percentages obtained in this investigation differ significantly between the two groups. These data therefore indicate that the stresses associated with flying have no more effect on serum lipids than do the stresses experienced by a group of non-flying officers. A corollary inference is that the prognostic significance of a given serum lipid level is the same whether observed in a flying or a non-flying officer.
Author

N74-13804 Advisory Group for Aerospace Research and Development, Paris (France)
THE PROBLEM OF DIABETES MELLITUS IN AVIATION MEDICINE
Gerhard Renftle *In its* Pathophysiol. Conditions Compatible with Flying Oct 1973 7 p refs (For availability see N74-13784 05-04)
Problems in aviation medicine which diabetes mellitus raise (regulations, waivers, diet, and hypoglycemic agents) are discussed. While the incidence rate is relatively low in student pilots, a higher number of cases is found during follow-up examinations among experienced senior or command pilots. Onset at age 20 to 40 may have the course of either juvenile or adult type. Annual evaluation of carbohydrate metabolism with a standard glucose tolerance test should be mandatory for every military or commercial pilot, and every private pilot after age 40. As sulfonylureas may cause hypoglycemia, any antidiabetic therapy should not be considered compatible with flying duties. Individuals with decreased carbohydrate metabolism tend to hypoglycemic reactions especially in hazardous situations or fasting periods. Waivers should be granted only for diabetic pilots whose carbohydrate metabolism is fully controlled with diet, confirmed by daily testing of urine and frequent postprandial blood sugar examinations. A case report illustrates the fluctuating and reversible course of an incipient diabetes and its effective management in a highly motivated and cooperative senior pilot.
Author

N74-13805 School of Aerospace Medicine, Brooks AFB, Tex
THE REPEATABILITY OF AN ABNORMAL 2-HOUR GLUCOSE TOLERANCE TEST
J F Trabal, R G Troxler, and M C Lancaster *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 5 p refs (For availability see N74-13784 05-04)
The diagnosis of diabetes mellitus not only implies a chronic abnormality of carbohydrate metabolism and an increased risk of premature vascular disease, but in the flyer, this diagnosis implies an increased risk to flying safety by reason of physical performance degradation. The glucose tolerance test (GTT) is the accepted standard for the diagnosis of nonmanifest diabetes. A study of the repeatability of the 2-hour GTT was carried out in 162 flyers who had an initial GTT and a repeat GTT from 6 - 24 months later. Of those initial tests considered abnormal, 55 to 60% reverted to normal on the repeat test. The repeatability of the GTT varied with the criteria used and with the number of points on the GTT curve that was considered. The effects of stress on glucose metabolism and the results of the modification of the criteria for the diagnosis of diabetes are discussed. The results of this study illustrate the importance of basic definitions of diagnostic criteria for diseases which have a long term effect on the health of the flying population.
Author

N74-13806 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
GERMAN AIR FORCE EXPERIENCES WITH CERTAIN CRITERIA FOR GRANTING A WAIVER
Guenther Schirrmann *In* AGARD Pathophysiol Conditions Compatible with Flying Oct 1973 4 p refs (For availability see N74-13784 05-04)
During a period of 13 years there were 28,699 periodic physical examinations of aircrew with 602 granted waivers. These medical waivers were primarily granted in the disciplines of ophthalmology and internal medicine and seem to be justified even after a critical review. Prerequisite to this procedure is not only a profound medical knowledge and know-how, but also comprehensive flight surgeons experience. A correlation of accidents/incidents caused by pilots with and without waivers indicates practically identical findings: while the aircraft accident rate was 3.76% for pilots flying without a waiver, it was 3.45% for pilots flying with a waiver and is therefore identical. An analysis of aircraft accidents involving the waiver group revealed

no evidence indicating that waivers are a triggering or contributing factor in accidents. The procedure seems to be sufficient to eliminate all flying safety risks. Author

N74-18779# Advisory Group for Aerospace Research and Development, Paris (France).
CLINICAL PSYCHOLOGY AND PSYCHIATRY OF THE AEROSPACE OPERATIONAL ENVIRONMENT
P. J. OConnor, ed. (Roy. Air Force Central Med. Est.) Dec. 1973 88 p refs Presented at AGARD Aerospace Med Panel Specialists Meeting, Soesterberg, Netherlands, 6 Sep 1973 (AGARD-CP-133) Avail NTIS HC $3.50

Stresses inherent in the military aircrew role are summarized. Summary data cover life stresses, relationship of domestic stress to operational efficiency, and motivation. Data are also given on structural anomalies of the brain and its effects on flying and phobic flight reaction. Several methods of treating psychiatric illness are included. For individual titles, see N74-18780 through N74-18791.

N74-18780 Gaustad Mental Hospital, Oslo (Norway). EEG Research Inst.
MENTAL AND PHYSIOLOGICAL ENVIRONMENTAL REQUIREMENTS IN MANNED FLIGHTS
C. W. Sem-Jacobsen *In* AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 6 p refs (For availability see N74-18779 10-04)

A study was made of the training and maintenance of today's pilot with respect to his physiological and mental environment. Special attention was placed on a complete monitoring of pilots under operational conditions to map out his tolerance and requirements for full efficiency. E.H.W.

N74-18781 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
FEAR OF FLYING AND ITS TREATMENT
K. Gerbert and H. Oberholz *In* AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 6 p refs (For availability see N74-18779 10-04)

A clinical effort was made to treat and return to flying status, pilots in whom psychic, performance, and behavioral irregularities were cited. Particular attention was given to pilots with fear of flying. Treatment was based on quasi-therapeutic interviews, conflict centered counseling, physical exercise therapy, and individually directed flying rehabilitation programs. E.H.W.

N74-18782 Royal Air Force Central Medical Establishment, London (England)
RESULTS OF BEHAVIOUR THERAPY IN FLYING PHOBIA
P. J. OConnor, J. A. Lister, and J. W. Rollins *In* AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 3 p (For availability see N74-18779 10-04)

The treatment of military crews and pilots for flying phobia by behavior therapy is discussed. Treatment was divided into three series. In series 1 seven cases were treated. Only men who were highly motivated towards military flying and possessed a robust personality were selected. Sixteen consecutive cases were treated in Series 2. No selection was made, all personnel diagnosed as having flying phobia were admitted for treatment. After evaluating the results it was decided to revert to treating select cases. Series 3 had eight cases. All men selected because they had good prognosis for recovery. It was concluded that there is a better chance of improving a pilot with flying phobia to the point where he can fly training type aircraft than for getting him well enough to return to high performance aircraft. Author

N74-18783 Royal Air Force, Farnborough (England)
ASSESSMENT OF BEHAVIOUR THERAPY IN THE TREATMENT OF FLYING PHOBIAS
A. B. Goorney *In* AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 7 p refs (For availability see N74-18779 10-04)

An accurate assessment of the effectiveness of behaviour therapy (or of any other therapeutic method) in the treatment of flying phobias is difficult due to lack of information. Nevertheless there is evidence to suggest that for selected cases behaviour therapy may be an effective treatment with a high percentage returned to full flying. Selection should be restricted to cases in whom anxiety is limited to a part of the total flying environment (focal anxiety). A mixed technique is suggested in which emotional control is regained through non-reinforcement. Author

N74-18784 Royal Air Force Central Medical Establishment, London (England).
DEPRESSION IN AIRCREW
P. J. OConnor, A. W. Black, and J. W. Rollins *In* AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 2 p (For availability see N74-18779 10-04)

Treatment and disposal of depressive illness in air crews are analyzed. Common etiological factors of the illness are listed. Author

N74-18785 Centre Medical de Psychologie Clinique de l'Armee de l'Air, Paris (France)
CLINICAL STUDY OF LOSS OF AERONAUTICAL MOTIVATION [ETUDE CLINIQUE DES PERTES DE MOTIVATION AERONAUTIQUE]
R. Gelly *In* AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ. Dec. 1973 4 p In FRENCH (For availability see N74-18779 10-04)

Factors accountable for the loss of motivation or interest in flying by military crew trainees are examined. Some of the motivation loss was attributed to social and flight stress, expectations of trainee not met during training period, and psychological and psychiatric aptitude of trainee is exceeded by training. Transl. by E.H.W.

N74-18786 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
PARTIAL CEREBRAL HYPOXIC ATTACKS IN PILOTS AS CAUSE OF HYPOXIA INCIDENTS
H. Oberholz *In* AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 4 p refs (For availability see N74-18779 10-04)

Screening methods for detecting and avoiding as well as determining the causes of cerebral hypoxic attacks in pilots during flying missions are introduced. Special attention was given to anomalies and variants of brain arteries, especially the Circle of Willis as the possible source of the attacks. Two case histories along with symptoms of the attacks are outlined. It was concluded from the data that the Circle of Willis in combination with hypoxia, low G forces, mental stress, extreme heat, and any kind of exhaustive or vestibular stimuli cause cerebral attacks. E.H.W.

N74-18787 School of Aerospace Medicine, Brooks AFB, Tex. Neuropsychiatry Branch
CHARACTERISTICS OF LIFE STRESS IN A POPULATION OF MILITARY AVIATORS
Carlos J. G. Perry and John W. Gaines *In* AGARD Clin Psychol and Psychiat of the Aerospace Operational Environ Dec 1973 2 p (For availability see N74-18779 10-04)

A description is given of a military aviator population with respect to the occurence of life stress events in its individual members. Questionnaires, inventories, and checklists were deliberately avoided to emphasize a broad range of freedom for the interviewer. During the course of such an interview life stress events were discovered that are missed by questionnaires. This was especially true of anniversary stress which was revealed only through persistent, patient questioning. A total of 320 life stress events were found during the study. Job stress was most frequently represented with personal health, marital, and parental relationships following in order of frequency. Author

N74-18788 Centre de Medecine Aeronautique, Brussels (Belgium)
SELECTION OF STUDENT PILOT CANDIDATES OF THE

BELGIAN AIR FORCE BY PSYCHOMOTOR TESTS [SELECTION DES CANDIDATS ELEVES-PILOTES DE LA FORCE AERIENNE BELGE PAR DES TESTS PSYCHO-MOTEURS]

J. Clement and J. Pardaens *In* AGARD Clin. Psychol. and Psychiat. of the Aerospace Operational Environ. Dec. 1973 11 p refs In FRENCH (For availability see N74-18779 10-04)

The predictive value of psychometric tests in investigating a sample of 413 student pilots and determining their fitness as future pilots is reported. The tests are used in conjunction with a linear method to select candidate student pilots. Results of the tests are given in tables and graphs Transl. by E.H.W.

N74-18788 Centre de Medecine Aeronautique, Brussels (Belgium).

PERSONALITY TRAITS AND FLIGHT APTITUDE [TRAITS DE PERSONNALITE ET APTITUDE AU VOL]

VanMassenhove and Flion *In* AGARD Clin. Psychol. and Psychiat. of the Aerospace Operational Environ. Dec. 1973 8 p In FRENCH (For availability see N74-18779 10-04)

Szondi's psychological testing method was used to determine the fitness and flight aptitude of student pilots. In particular an attempt was made to determine personality traits and correlate them with flight aptitude. Seventy nine student pilots were tested using two groups designated as Group A and Group B. Group A students were just entering training and Group B students were ending their training. A comparison was made of the two Groups' response to different flight environments. Detailed results are given in graphs Transl. by E.H.W.

N74-18790 Italian Air Force Aerospace Medical Center, Rome.

IN-FLIGHT PSYCHIC LOAD IN STUDENT-PILOTS, EVALUATED BY MEANS OF VANIL MANDELIC ACID (VMA) CHANGES IN URINARY EXCRETION

G. Paolucci and G. Blundo *In* AGARD Clin. Psychol. and Psychiat. of the Aerospace Operational Environ. Dec. 1973 2 p refs (For availability see N74-18779 10-04)

Sixty four air cadets were tested for in-flight psychic load and anxiety crises by vanil mandelic acid content in the urine. The tests were made in an effort to determine possible preexcisting stress and the measurement of its degree. It was suggested that VMA content is proportional to the amount of stress, and that this method should be included in tests for selecting pilots. Author

N74-18791 Royal Netherlands Air Force the Hague.

INFLUENCE OF SOCIAL/RELATIONAL FACTORS ON OPERATIONAL FLYING CAPACITY: A SYSTEM-ORIENTED APPROACH

H. Merkus and J. J. VanderMaas *In* AGARD Clin. Psychol. and Psychiat. of the Aerospace Operational Environ. Dec. 1973 5 p refs (For availability see N74-18779 10-04)

The effectiveness of the psycho-social approach to treating military pilots with psychological problems or symptoms of such problems is examined. After an explanation about the viewpoints of the psycho-social model, a description is given of how the model is made applicable in psychiatric practice. Three case histories are presented to illustrate the use of the model. Author

N74-22727# Advisory Group for Aerospace Research and Development, Paris (France)

MANUAL OF AERONAUTICAL MEDICINE AND APPLICATION TO NAVIGATION PERSONNEL [MANUEL DE MEDECINE AERONAUTIQUE A L'USAGE DU PERSONNEL NAVIGANT]

T. G. Dobie (RAF) Dec. 1972 280 p In FRENCH (AGARDograph-154(FR); AGARD-AG-154(FR)) Avail: NTIS HC $17.00

Diverse aerospace medical data are summarized. Summaries cover mental and physical health, respiration and circulation, hypoxia prevention, pressure reduction effects, and effects of extreme heat on the body. Data are also given on air sickness, noise and vibration, cabin pressurization and rapid decompression, vision, and survival. Several other related topics were also summarized. Transl. by E.H.W.

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05 BIOTECHNOLOGY

Includes life support systems, human engineering; protective clothing and equipment; crew training and evaluation, and piloting. For related information see also: 04 Biosciences.

N71-22301# Advisory Group for Aerospace Research and Development, Paris (France).

PHYSICAL FITNESS IN FLYING INCLUDING THE AGING AND AGED AIRCREW

H. W. Kirchhoff, ed. Mar 1971 173 p refs Presented at the Specialist Meetings of the Aerospace Med. Panel of AGARD, Garmisch Partenkirchen, West Germany, 21-22 Sep 1970 (AGARD-CP-81-71) Avail NTIS

Physical fitness and pilot performance in connection with physiological training are considered. A variety of the symptoms of the aging process are described and their effects on the performance of flying personnel are considered. For individual titles see N71-22302 through N71-22321.

N71-22302# Clemenshospital, Muenster (West Germany)

PHYSICAL FITNESS AND FLYING

Alfred Koch *In* AGARD Phys Fitness in Flying including the Aging and Aged Aircrew Mar 1971 16 p refs (See N71-22301 11-05)

Avail NTIS

The term fitness is described and defined as a state which characterizes the degree to which the human organism is able to function. Measurements of physical fitness aptitude and of the factors that impair or improve fitness are discussed in relation to flying aircrews. G G

N71-22303# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).

METHODS OF MEASURING PHYSICAL FITNESS

H. W. Kirchhoff *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 5 p (See N71-22301 11-05)

Avail NTIS

Single stage, non-steady state, submaximal exercise procedures are commonly used in diagnostic and functional testing. The principal modes of imposing the workload are step climbing, bicycle ergometer riding and treadmill walking. These tests are generally available and safe. Despite many real and hypothetical deficiencies, they may yield, when standardized, qualitative and quantitative information of considerable value to individual clinical evaluations and to group comparisons. Steady state submaximal exercise tests determine a great number of values (V sub O2, V sub CO2, RQ, V sub E, specific ventilation, oxygen pulse, pulse rate, blood pressure and the ECG). Vita maxima tests are utilized to determine the maximum values of oxygen consumption and the physical working capacities. Author

N71-22304# Army Research Inst. of Environmental Medicine, Natick, Mass. Military Ergonomics Lab

PHYSICAL FITNESS, FLIGHT REQUIREMENTS AND AGE

Ralph F Goldman *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 9 p refs (See N71-22301 11-05)

Avail NTIS

Muscular strength, cardio-respiratory capacity and relative body weight are frequently used criteria of physical fitness. These different aspects of fitness all alter predictably with age and can be altered by training. Considering the physical work involved in flight, it seems appropriate to consider to what degree physical fitness -- and which aspects of it -- should be important to an aircrew. Excess weight may require premature replacement of an individual because of the decreased longevity associated with being overweight, but should not hinder flight performance as long as the man fits into his workspace, and agility and reach are unimpaired. The energy cost of flying only averages 125 kcal/hr and even an average 65 year old in fair condition has a maximum work capacity at least 3 times that. Finally, the muscular forces required to fly modern aircraft are minimized by electro-mechanical control systems. Author

N71-22305# Canadian Armed Forces Inst. of Environmental Medicine, Toronto (Ontario)

PHYSICAL FITNESS AS PART OF AIRCREW TRAINING

C. L. Allen *In* AGARD Phys. Fitness in Flying Including the Aging and Aged Aircrew Mar. 1971 9 p (See N71-22301 11-05)

Avail NTIS

Physical fitness development of aircrew candidates in the Canadian Forces is an integral part of their training. Schedules have been established and promulgated for all levels of training from newly enrolled cadets to the advanced flying school stages. While all of the standard elements of physical conditioning, such as calisthenics, resistance training and sports activities are included, the emphasis is on cardio-respiratory development. Regular assessments of candidates are carried out, using the 12-minute distance as the vehicle for testing. All personnel are expected to maintain a good category, i.e. at least 1.50 miles in 12 minutes for ages under 30 years with a suitable reduction for older candidates. Author

N71-22306# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Bad Godesberg (West Germany). Institut fuer Flugmedizin

PHYSICAL TRAINING STATUS IN RELATION TO STRESS TOLERANCES

H. M. Wegmann and K. E. Klein *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 11 p refs (See N71-22301 11-05)

Avail NTIS

The influence of physical fitness on stress tolerance was studied by comparing two different groups of subjects, one group including 11 highly trained athletes and the other group consisting of 11 untrained and unadapted students. Both groups were uniformly subjected to hypoxia, acceleration, exercise, and orthostatic stress, applying maximal loads for evaluating tolerances and submaximal loads for studying cardiovascular and hormonal stress responses. In summarizing the results the following conclusions were obtained. A better physical fitness does not imply higher tolerances to stressors other than exercise. There is no indication which supports the idea of an improvement of human tolerance to environmental extremes by physical exercise training. Author

N71-22307# German Air Force, Porz-Wahn (West Germany)

PHYSICAL CONDITIONING TRAINING AND FITNESS TEST OF GERMAN AIR FORCE AIRCREWS

W. Hill *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 7 p ref (See N71-22301 11-05)

Avail NTIS

Physical conditioning training and fitness tests for German Air Force flying crews are considered as an alternative to the United States of America's Aerobics Physical Fitness Program. The purpose of both programs is to improve the physical conditions of aircrew members until the levels of optimum fitness are attained and thereafter to maintain these high levels for as long as possible. There are, however, essential differences in the application of the two methods. Author

N71-22308# Army Personnel Research Establishment, Byfleet (England)

EXERCISE TOLERANCE OF MILITARY PERSONNEL

M F Haisman *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 6 p refs (See N71-22301 11-05)
Avail NTIS

The exercise tolerance of British Army personnel has been investigated by means of estimates of maximal oxygen intake (Vo2 max) and the Harvard step test. Vo2 max was estimated from heart rates, recorded during performance of standardized exercises on stepping stools or bicycle ergometers. About 650 men have been included in the study. The results have indicated that estimated Vo2 max provided an index of fitness suitable for application to large groups of men, in that it was reproducible, and sensitive in respect of separating groups of trained and untrained men and in detecting the improvements in fitness associated with intensive physical training. The Harvard step test results were of broadly similar pattern to the Vo2 max results but reproducibility was poorer. Men with a high body fat content showed a marked tendency to have a low Vo2 max. Author

N71-22309# Strasbourg Univ (France) Inst Dentaire
AERONAUTICAL FACTORS AND TOOTHACHE INCIDENCES DURING FLIGHT [FACTEURS AERONAUTIQUES ET INDIVIDUELS DES DOULEURS DENTAIRES EN VOL]
R Frank, J M Debruge, and A M Pfister *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 8 p refs In FRENCH; ENGLISH summary Prepared jointly with Centre d'enseignement et de Rech de Med Aeron (See N71-22301 11-05)
Avail NTIS

A recent investigation made on 230 conventional and jet aircraft pilots in the French Air Force has provided a comprehensive picture of the incidence of toothache in flight and of its favoring factors. Over a year of observations it was found that 6.52% of the investigated pilots suffered from toothaches in flight. Pains developed according to a rather characteristic process during the various phases of flight: (1) chronic pulpitis induces short lived, progressively appearing throbbing type pains which appear mostly during climbs, (2) wisdom teeth and periapical reactions on mortified teeth or improperly stopped radicular canals rather induce pains during descents, and (3) periapical granulomas become painful in cruise flights without any marked speed variations; the induction of such neuralgias is related, among other reasons, to the vibrations experienced by the pilot. Author

N71-22310# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
COMBINED ENVIRONMENTAL, EMOTIONAL, AND PHYSICAL ACTIVITY THERAPY: A MODERN PREVENTIVE AND RECONDITIONING PROGRAM
J D Meyer-Erkelenz *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 14 p refs (See N71-22301 11-05)
Avail NTIS

Physical exercise training combined with environmental, emotional and Terrain Kur effects is an optimal therapy in preventing and reconditioning treatment of civilization and hypokinetic diseases, because a predominantly neuro-vegetative alteration in the whole body takes place. The results on heart, respiration, muscles, vascular, metabolic, hormonal, CNS and other organic systems are detailed. The physical fitness of German Air Force pilots is maintained or increased by (1) exercise training designed for individual performance, and (2) the active cure treatment with multiple additional therapeutic elements, e.g. sauna, hydrotherapy, skin brush massage, etc. The gymnastic exercises are described and illustrated. Positive success is demonstrated in measurable facts and stress tests before, during and after the 4 weeks of cure. Author

N71-22311# Canadian Armed Forces Inst of Environmental Medicine, Toronto (Ontario)
AEROBIC CAPACITY SURVEY: CANADIAN FORCES PERSONNEL
C L Allen *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 4 p refs (See N71-22301 11-05)
Avail NTIS

The maximum oxygen intake of a representative sample of 1004 Canadian Forces personnel has been c[illegible]mined. The daily activity patterns as well as heights, weights, skinfold thicknesses and smoking histories were also recorded. The values for aerobic p[illegible]ver are similar to those reported for other N American groups in the same age range. The levels of daily activities and smoking histories have measurable effects on the endurance fitness of these personnel. Author

N71-22312# Erlangen-Nuremberg Univ (West Germany)
FUNDAMENTAL SUBJECTS OF GERONTOLOGY AND PARTICULARITIES OF GERIATRICS
R Schubert *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 4 p (See N71-22301 11-05)
Avail NTIS

The biological aspects of senescence are considered. For the purpose of performing systematic work in this field it is necessary to differentiate and clearly define the various forms of calendar based or chronological senescence. Besides this form of senescence governed by the unbiased time factor, there is also the most important form of biological senescence, including the two sub-forms of physiological and psychological aging. The psychological chronograph records the personal time of an individual; the decisive factor being the experiences the individual has lived through during that period. Physiological senescence is determined by the development, growing and aging of morphae and the functions of organs. The most rigorous criteria are imposed by calendar time, which sets absolutely unbiological upper and lower age limits. The problem of flexible age limits is once more becoming most important. Author

N71-22313# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
PHYSICAL ACTIVITY AND AGING
H W Kirchhoff *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 5 p (See N71-22301 11-05)
Avail NTIS

There appears to be acceptable evidence that exercise does affect biochemical and physiological parameters related to ischemic heart disease and to the myocardium itself. It is remarkable that a physical fitness program of the German Institute of Aviation Medicine had an extraordinarily good effect on blood pressure, ECG and other parameters. Since this program was begun, increases in blood pressure have been considerably less frequent. There occurred a lowering of the heart rate at rest and during exercise, an improvement of orthostatic tolerance, normalisation of exercise induced hypoxic electrocardiographic changes at low oxygen pressure and an increase of oxygen uptake, respiratory volume and oxygen pulse during physical effort. These data corroborate the concept of a preventive and rehabilitative value in physical and environmental-emotional conditioning programs. The training program provides objective evidence for a clearly favorable influence of conditioning periods on cardio vascular function of the aging pilot. Author

N71-22314# Naval Aerospace Medical Inst, Pensacola, Fla Naval Aerospace Medical Research Lab
THE THOUSAND AVIATORS: A THIRTY YEAR FOLLOW UP

R E Mitchell, A Graybiel, A Oberman (Ala Univ), and W R Harlan (Ala Univ) *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 5 p (See N71-22301 11-05)
Avail NTIS

The thousand aviator project is a longitudinal study with the emphasis primarily on defining new physical standards for aviators and secondarily on an epidemiological study of aging The present report is limited to a discussion of the electrocardiographic and blood pressure findings Longitudinal changes in the resting electrocardiograms have shown that those individuals with a decrease in QRS amplitude and a leftward movement of the QRS vector appear to have a tendency to develop coronary artery disease Some of the men in the group have shown a consistent rise in blood pressure apparently related to weight gain and parental longevity Otherwise there are no means by which the blood pressure pattern of an aging individual can be predicted Author

N71-22315# Canadian Armed Forces Inst of Environmental Medicine, Toronto (Ontario)
MORBIDITY OF AIRCREW IN THE CANADIAN FORCES IN RELATION TO AGE
W J C Stevenson *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 8 p (See N71-22301 11-05)
Avail NTIS

One of the factors in the consideration of the aging process in aircrews is the relationship of illness, injury, and physiological incidents Evaluations of 268 pilots and air navigators, representing 6 8% of the established Canadian aircrew strength were carried out because individuals either failed to meet prescribed medical standards or else had developed some difficult, obscure or border-line medical problems which raised a question of fitness to continue flying Data indicate that diseases of the circulatory system were cause for removal from flying duties of the largest number of older aircrew members, while psychiatric disorders resulted in the greatest number of groundings in the younger group Author

N71-22316# School of Aerospace Medicine Brooks AFB Tex
THE EFFECTS OF AGING ON BODY COMPOSITION AND EXERCISE PERFORMANCE IN THE USAF AIRCREW POPULATION
John W Ord and Malcolm C Lancaster *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 10 p refs (See N71-22301 11-05)
Avail NTIS

Nine hundred seventeen healthy aircrewmen ranging in age from 25 to 49 years were evaluated for minor medical findings During the same period, 348 pilots were evaluated as part of the selection process for special projects such as space flight The differences between the groups and in subgroups according to age in parameters bearing on physical fitness are described The special project group was more fit than the other normal group as demonstrated by their response to maximal treadmill testing had a lesser body fat fraction and lower blood lipid and glucose levels Older subgroups demonstrated lower maximal treadmill exercise performance, had higher body fat fractions and tended to demonstrate higher levels of blood lipids and glucose Author

N71-22317# School of Aerospace Medicine Brooks AFB Tex
A COMPARISON OF THE EFFECTS OF EARLY CARDIOVASCULAR DISEASE AND AGING UPON MAXIMAL EXERCISE PERFORMANCE IN THE USAF AIRCREW POPULATION
Malcolm C Lancaster and John W Ord *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 8 p refs (See N71-22301 11-05)
Avail NTIS

The influence of early, mild cardiovascular disease upon maximal exercise performance in 544 flyers, ages 40-49 years was considered There were 300 normal subjects, 64 subjects with non-specific repolarization changes on the electrocardiogram 114 subjects with hypertension and 66 subjects with coronary heart diseases The NSTWC and hypertensive groups had significantly higher body fats than normals There were no significant differences between the disease groups and normals with respect to blood sugar and serum lipids Both the hypertensive and CHD groups had significantly lower maximal oxygen consumptions and total treadmill times than normals Systolic blood pressures in all disease groups were significantly higher at rest than in normals Systolic blood pressure increased as expected in normals and a parallel increase was seen in the disease groups Diastolic blood pressure was unchanged at maximal exercise in normals, while all disease groups were significantly higher Blood pressure levels in the hypertensive group were significantly higher at rest than the other disease groups and remained proportionately higher with exercise Author

N71-22318# Centre Principal d Expertises Medicales du Personnel Navigant Paris (France)
TRACING OF ARTERIOSCLEROSIS DURING EVALUATION OF FLYING PERSONNEL [DEPISTAGE DE L'ATHEROSCLEROSE DANS L'EXPERTISE DU PERSONNEL NAVIGANT]
R Carre, J Salvagniac and F Plas *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 9 p refs In FRENCH (See N71-22301 11-05)
Avail NTIS

Cardiovascular abnormalities in more than 3000 flying personnel were studied during a 12 year period by performing electrocardiographic, cholesterol content, and carotidogrammetric evaluations It was established that more than 30% of the disabled group had cardiovascular diseases with the greatest number found between 45 to 50 years of age, aging personnel were more accident prone and pilots of the French Air Force were grounded if they showed typical arteriosclerotic symptoms Also grounded were pilots over 40 years of age with ECK abnormalities
Transl by G G

N71-22319# Institute of Aviation Medicine Fuerstenfeldbruck (West Germany)
PSYCHOPHYSIOLOGICAL PROCESSES OF AGING
H J Grunhofer and K Gerbert *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 7 p refs (See N71-22301 11-05)
Avail NTIS

Facts observed so far concerning variations and decrement of cognitive, psychomotoric and retentive abilities with increasing age are reported Generally it can be assumed that almost all psychophysical performance functions decrease as of the third decade of life But abilities with increasing age are essentially dependent upon the level of original aptitude type and extent of experience gained in the course of life thinking patterns, and trained procedures consolidated through exercise On the other hand particular decreasing capabilities can only be compensated by others within certain limits As a result adjustment and readjustment to requirements which cannot be met by means of confirmed behavior became increasingly difficult An analysis of presently used methods to measure flying proficiency in aging pilots is given
Author

N71-22320# Institute of Aviation Medicine Fuerstenfeldbruck (West Germany)
HEARING ACUITY IN RELATION TO AGE AND FLYING TIME
G R Froehlich *In* AGARD Phys Fitness in Flying Including the Aging and Aged Aircrew Mar 1971 8 p (See N71-22301 11-05)
Avail NTIS

The pure tone audiograms of 1024 Air Force pilots and 100 applicants were classified into 3 categories (Q1) the 25% with best hearing capacity, (Q2) the 50% with medium hearing capacity, (Q3) the 25% with poorest hearing capacity, and S hearing losses of industry population The evaluation had the following results (1) pilots classified as Q 1 and Q 2 had a hearing acuity that was slightly better or equal to comparative age groups of a normal industry population, (2) Even in the Q 3 groups with marked hearing losses, the main speech frequencies of 500 - 2000 Hz showed only negligible impairment, (3) the hearing acuity of jet-pilots is slightly better than that of pilots in helicopters and propeller aircraft, and (4) for the decrease in hearing acuity age is more important than flying time Author

N71-22321# Centre de Medecine Aeronautique, Brussels (Belgium)
LONGITUDINAL STUDY OF SPIROMETER VALUES FOR NAVIGATOR PERSONNEL OF THE BELGIAN AIR FORCE [ETUDE LONGITUDINALE DES VALEURS SPIROMETRIQUES DU PERSONNEL NAVIGANT DE LA FORCE AERIENNE BELGE]
J Bande *In* AGARD Phys Fitness in Flying including the Aging and Aged Aircrew Mar 1971 7 p (See N71-22301 11-05)
Avail NTIS

Long term spirometric measurements on Belgian Air Force flying personnel obtained over a period from 5 to 10 years, are evaluated in order to establish the influence of aging on physical fitness concurrent with the process of aging A new special formula is presented that is applicable for ages 15 through 55 and can be used to predict the developing vital capacity for each individual subject during aging Transl by G G

N71-23337# Advisory Group for Aerospace Research and Development Paris (France)
PRINCIPLES OF BIODYNAMICS APPLICABLE TO MANNED AEROSPACE FLIGHT PROLONGED LINEAR AND RADIAL ACCELERATION
Mar 1971 182 p refs
(AGARDograph 150 AGARD AG 150 71) Avail NTIS

CONTENTS

N71-23338# Advisory Group for Aerospace Research and Development Paris (France)
ACCELERATION TERMINOLOGY TABLE OF COMPARATIVE EQUIVALENTS
G J Pesman *In its* Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration Mar 1971 p 1 6 refs (See N71 23337 12-05)
Avail NTIS

Development of vertical or steep landing and takeoff aircraft helicopters and space vehicles has destroyed the comfortable situation in which the vehicle and occupants maintained a fixed relationship With the advent of these advances it became desirable that essentially two directional terminologies be used one for the vehicle and another for the occupants Terms were evolved and as far as possible have been incorporated into revised tables of equivalent terminology for both linear and angular motion Tables of comparative equivalents are presented which are organized into the form of a statement of the laws of motion A L

N71 23339# Advisory Group for Aerospace Research and Development Paris (France)
AN INTRODUCTION TO THE PHYSICS AND PHYSIOLOGY OF ACCELERATION
S D Leverett Jr *In its* Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration Mar 1971 p 7 24 (See N71 23337 12 05)
Avail NTIS

The history of acceleration and its relation to aviation medicine is reviewed along with a brief discussion of the conventional terminology for describing these forces and the physiological effects and clinical responses of the human body to these forces A L

N71-23340# Advisory Group for Aerospace Research and Development Paris (France)
THE DYNAMICS OF ROTATION APPLIED TO CENTRIFUGES
R E van Patten *In its* Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration Mar 1971 p 25 36 (See N71 23337 12 05)
Avail NTIS

An intuitive graphical and simplified mathematical treatment is presented on the subject of rotational dynamics as applied to human centrifuges This approach was taken in order to relieve physicians and medical personnel of the labor required to gain a rigorous insight into the subject and to strip away the non essentials associated with the classic development Definitions are presented of the terms associated with the subject as they are commonly used and misused Coriolis acceleration is discussed and some examples of Coriolis effects are provided A L

N71 23341# Advisory Group for Aerospace Research and Development Paris (France)
A SUMMARY OF HUMAN TOLERANCE TO PROLONGED ACCELERATION
A S Hyde and H W Raab *In its* Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration Mar 1971 p 37 56 refs (See N71 23337 12 05)
Avail NTIS

A summary of data from literature on human tolerance to prolonged acceleration is presented in tabular and graphical form. Standard terminology derived from an AGARD NATO agreement on the equivalence of acceleration terminology is used. Most of the graphs present the magnitude ... [illegible] ... and the duration of the exposure ... [illegible] ... Separate groups of graphs are recorded for each direction of acceleration. Each group of graphs is further divided on the basis of the ... [illegible] ... and the number of ... [illegible]

given and a table provided. Each table defines each point on each graph with respect to the following variables: vector magnitude, duration, average onset (G/second), back angle, cause of termination of experimental exposure, trauma, number of subjects involved, countermeasures used, support, restraint, and the reference from which this information was obtained. A.L.

N71-23342# Naval Aerospace Medical Inst. Pensacola, Fla.

DESCRIPTIVE CATALOG OF AEROSPACE MEDICAL BIODYNAMICS FACILITIES IN THE UNITED STATES AND CANADA

Charles F. Gell, ed. *In* AGARD Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration Mar. 1971 p 57-100 (See N71-23337 12-05)

Avail: NTIS

A descriptive text and pictorial display are presented of the newest equipment and latest modifications of older equipment used in biodynamic studies conducted in United States Government facilities and in Canadian facilities. Facilities and equipment discussed are located at: (1) Naval Aerospace Medical Institute, (2) Aerospace Medical Research Department, (3) Aerospace Crew Equipment Laboratory, (4) 6570th Aerospace Medical Research Laboratories, (5) 6571st Aeromedical Research Laboratory, (6) United States Air Force School of Aerospace Medicine, (7) Manned Spacecraft Center, (8) Ames Research Center, (9) Civil Aeromedical Institute, (10) National Aviation Facilities Experimental Center, (11) Section of Physiology, Mayo Foundation and Mayo Clinic, and (12) Defense Research Establishment, Toronto, Canada. A.L.

N71-23343# Military School of Aviation Medicine, Rome (Italy).

BIODYNAMICS FACILITIES IN NATO EUROPEAN COUNTRIES

Aristide Scano, ed. *In* AGARD Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration Mar. 1971 p 101-124 refs (See N71-23337 12-05)

Avail: NTIS

Photographs and descriptive texts are presented of facilities and equipment for biodynamic studies and research in France, Italy, and England. A.L.

N71-23344*# National Aeronautics and Space Administration, Washington, D.C.

BIODYNAMICS BIBLIOGRAPHY, 1966-1969

Walton L. Jones, comp. *In* AGARD Principles of Biodynamics Applicable to Manned Aerospace Flight Prolonged Linear and Radial Acceleration Mar. 1971 p 125-196 refs (See N71-23337 12-05)

(NASA-TM-X-67138) Avail: NTIS CSCL 06R

This annotated bibliography brings together recent information not available in earlier literature reviews, concerning biodynamic research findings. Coverage was international and provides a representative view of current research efforts. The abstracts were taken directly from the initial source documents. The bibliography is divided into six sections: (1) prolonged acceleration (linear and radial), (2) angular acceleration, (3) impact, (4) vibration, (5) combined stresses, and (6) general documents. A.L.

N72-14090# Advisory Group for Aerospace Research and Development, Paris (France).

CLINICAL CAUSES FOR GROUNDING

Heinz S. Fuchs Nov. 1971 192 p refs Presented at the AGARD Aerospace Med. Panel Specialist Meeting, Oporto, Portugal, 21-22 Jun. 1971

(AGARD-CP-89-71) Avail: NTIS

Papers given at the AGARD Aerospace Medical Panel Specialist Meeting held in Oporto, Portugal from 21 to 22 June 1971 are presented. The subject was divided into two parts: the general aspects of clinical causes for grounding in the various air forces, and the specific aspects of grounding according to medical specialties. Each paper is followed by a discussion. A technical summary and an evaluation are included at the end. For individual titles, see N72-14091 through N72-14102.

N72-14091# Italian Air Force Medico Legal Inst., Milan.

STATISTICAL SURVEY ON THE CLINCIAL CAUSES OF TEMPORARY GROUNDING AND PERMANENT UNFITNESS OF IAF AIRCREWS

Gaetano Rotondo *In* AGARD Clinical Causes for Grounding Nov. 1971 29 p refs (See N72-14090 05-05)

Avail: NTIS

An analytical study of the clinical causes that most frequently lead to temporary or permanent loss of fitness among flying personnel was undertaken. A wide statistical survey was made on morbidity, or rather some aspects of morbidity, in the personnel of the Italian Air Force, among the various categories or groups of categories connected with the flying service in general and with particular regard to pilots. Such a study was undertaken with the hope of detecting the physio-psychic causes that have most weight and incidence in giving rise to unfitness for military service and for flying. It would then be possible to make practical suggestions in order to reduce the incidence of these causes and their disabling effects. Author

N72-14092# Royal Naval Air Medical School, Hilhead (England).

CLINICAL CAUSES FOR GROUNDING: A REVIEW OF ROYAL NAVAL EXPERIENCE, 1962-1970

I. H. Colley and F. St. C. Golden *In* AGARD Clinical Causes for Grounding Nov. 1971 11 p refs (See N72-14090 05-05)

Avail: NTIS

The clinical causes for permanent grounding in the British Fleet Air Arm for the period January 1962 to December 1970 inclusive were examined. Clinical groundings constitute 13% of the total groundings for all reasons. Psychiatric illness is responsible for 58% of clinical groundings and was the major cause of wastage in trained aircrews. Author

N72-14093# Belgian Air Force, Brussels.

ANALYTICAL STUDY OF THE CAUSES OF MEDICAL UNFITNESS OF FLYING PERSONNEL IN THE BELGIAN AIR FORCE [ETUDE ANALYTIQUE DES CAUSES D'INAPTITUDE MEDICALE DU PERSONNEL NAVIGANT DE LA FORCE AERIENNE BELGE]

J. Bande and R. Moorthamers *In* AGARD Clinical Causes for Grounding Nov. 1971 11 p In FRENCH (See N72-14090 05-05)

Avail: NTIS

A comprehensive analysis was made of the causes of temporary and permanent unfitness, in cases treated by the ad hoc Medical Commission of the Belgian Air Force from 1965 to 1971. The study concerned 635 subjects, of whom 29.5% had a number of different disabilities. 7.6% of the cases were the object of permanent grounding and 12.9% were permanently limited in their fitness for the air service. 40% of the cases were accident victims. Of 904 disabilities, the pathology of the locomotor system was the most frequent, involving afflictions of both the neuropsychiatric and digestive systems. After eliminating accident cases, the most frequent pathology was of the digestive and respiratory tracts. A study of the correlation between age of the subject and the length of disability as a function of pathological class gave no conclusive results. Transl. by K.P.D.

N72-14094# Naval Air Station, Norfolk, Va.

A REPORT OF AVIATOR GROUNDING AND AVIATOR SALVAGE IN HIGH PERFORMANCE FIGHTER AIRCRAFT

Romaine L. Bendixen *In* AGARD Clinical Causes for Grounding Nov. 1971 8 p refs (See N72-14090 05-05)

Avail: NTIS

The role of the flight surgeon in the United States Navy

and particularly the role of the dually designated physician-pilot is considered in the evaluation, treatment, and disposition of aviators flying in high performance jet fighter aircraft. Personal observations and experiences of the author as a pilot instructor-flight surgeon with a McDonnell F-4 (Phantom II) training squadron form the basis for the presentation and discussion of several cases involving the question of grounding for major clinical reasons. An integral part of these discussions is an attempt to demonstrate the value of the pilot-physician. This report covers a relatively short span of time, October 1967 through July 1969, but is particularly significant in the number of interesting cases that arose requiring evaluation and disposition. Author

N72-14095# School of Aerospace Medicine, Brooks AFB, Tex.
USAF AEROMEDICAL CONSULT SERVICE EXPERIENCE IN CAUSES FOR GROUNDING OVER THE PAST FIFTEEN YEARS
Malcolm C. Lancaster *In* AGARD Clinical Causes for Grounding Nov. 1971 7 p refs (See N72-14090 05-05)
Avail: NTIS

A marked change in the factors that relate to medical grounding of flyers in the United States Air Force (USAF) has occurred over the past 15 years. The increasing age of the flying population is the major causative factor producing this change. Improved diagnostic techniques and an increase in the fund of information about normals and individuals with early disease also had a significant influence upon both the types of problems evaluated and their disposition. The experience of USAF School of Aerospace Medicine over a period of 15 years is reviewed, and the trends and factors related to medical criteria for grounding USAF flyers are discussed. Author

N72-14096# Office of the Surgeon General (Air Force), Washington, D.C.
CAUSES FOR MEDICAL GROUNDING OF PILOTS AND NAVIGATORS IN THE UNITED STATES AIR FORCE, 1969
Robert A. Farmer and Howard R. Unger *In* AGARD Clinical Causes for Grounding Nov. 1971 6 p (See N72-14090 05-05)
Avail: NTIS

Specific indices and measures of the health of USAF-rated officers are computed from biometric data provided by the flight surgeon's medical recommendations. These data are discussed in relation to the health of Air Force flyers and the practice of aerospace medicine in the U.S. Air Force. Similarities and variations of medical practice and management are considered. Comparisons of the rates of removal and noneffective ratios by rating, age, and command are presented. Author

N72-14097# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany).
CLINICAL CAUSES FOR PERMANENT GROUNDING OF AIRCREW WITHIN THE GERMAN ARMED FORCES
H. J. Grunhofer and K. R. Mueller *In* AGARD Clinical Causes for Grounding Nov. 1971 9 p (See N72-14090 05-05)
Avail: NTIS

All clinical causes for permanent grounding of German armed forces pilots and other aircrew members were examined and analyzed statistically. The causes for medical disqualifications are divided into diagnostic groups or according to specific functions of organs and/or organ systems. Special emphasis is given to waivers and to certain psychological aspects. There were 24,396 physical examinations studied over a period of 11 years. Author

N72-14098# Centre Principal d'Expertises Medicales du Personnel Navigant, Paris (France). Service de Sante des Armees.
STATISTICAL ANALYSIS OF UNFITNESS OF FLYING PERSONNEL IN THE FRENCH AIR FORCE [STATISTIQUE DES INAPTITUDES DU PERSONNEL NAVIGANT DE L'ARMEE DE L'AIR FRANCAISE]
J. Nathie, P. M. Pingannaud, and A. Gibert *In* AGARD Clinical Causes for Grounding Nov. 1971 6 p In FRENCH (See N72-14090 05-05)
Avail: NTIS

The physical fitness of flying personnel in the French Air Force is supervised by the Centers for Medical Evaluation of Flying personnel. A general study of 60,811 review evaluations made by the centers from 1960 to 1969 show that, among 1400 causes of observed unfitness (temporary unfitness excluded), the most numerous were neuropsychiatric disorders (381 causes) and inadequacy of the visual function (379 causes). These conclusions were made precise in a detailed study of the results in 1969, during which year 72 subjects were declared unfit. It appears that unfitness of neuropsychiatric origin is essentially motivated by psychological or psychosomatic difficulties. The disabilities recorded rarely led to the elimination of flying personnel, the majority being eventually discharged or reclassified into another specialty. The importance of statistical problems is emphasized and their solution by electronic data processing methods is proposed. Transl. by K.P.D.

N72-14099# Hellenic Air Force General Hospital, Athens (Greece). Dept. of Internal Medicine.
MEDICAL ASPECTS OF GROUNDING AND NONEFFECTIVENESS IN HELLENIC AIR FORCE PILOTS
C. E. Giannopoulos and H. G. Vissoulis *In* AGARD Clinical Causes for Grounding Nov. 1971 5 p refs (See N72-14090 05-05)
Avail: NTIS

Based upon statistics from Greek pilots' individual health files, hospital records, and the Aviation Supreme Medical Board's certifications, a ten year analytical study of the medical causes of admissions, waivers, suspensions, and permanent groundings is presented. Data on the medical causes for elimination from flying training are also discussed comparatively. From an average strength of 642 rated pilots, 24 were permanently grounded for medical reasons. The major cause was due to sensory deficiencies which accounted for 9 groundings, or 37.5% of the total. Peptic ulcer disease is the most frequent cause for noneffectiveness and accounts for several permanent groundings. The incidence of coronary heart disease is exceptionally low and should be attributed to the younger age distribution of the surveyed population. The elimination of two cadets for thalassemia minor and the finding of several cases of thalassemia trait among rated pilots brings into focus the problem of thalassemia endemic in certain areas of Greece. Author

N72-14100# Naval Aerospace Medical Inst., Pensacola, Fla.
THE US NAVY SPECIAL BOARD OF FLIGHT SURGEONS KEEP THEM FLYING SAFELY
M. D. Courtney *In* AGARD Clinical Causes for Grounding Nov. 1971 12 p (See N72-14090 05-05)
Avail: NTIS

In 1957 the United States Navy's Bureau of Medicine and Surgery directed the establishment of the Special Board of Flight Surgeons. This board consists of specialists in aerospace medicine and related fields who can make recommendations concerning the physical qualifications of Navy and Marine Corps aircrew personnel which are necessary for them to continue in duty involving flying. The composition of the Special Board and its method of operation are described, and the kinds of cases referred to it for the past fourteen years and the recommendations made for the disposition of these cases are reviewed. Author

N72-14101# School of Aerospace Medicine, Brooks AFB, Tex.
CHANGING CONCEPTS IN MEDICAL REASONS FOR GROUNDING IN THE USAF AEROMEDICAL CONSULT SERVICE
John H. Triebwasser *In* AGARD Clinical Causes for Grounding Nov. 1971 9 p refs (See N72-14090 05-05)
Avail: NTIS

Flying safety is the major factor underlying medical decisions regarding a given aviator's fitness to fly. Over the past 15 years medical concepts were modified as experience with an older

population and newer diagnostic techniques was gained The incidence of degenerative disease has increased parallel with the age of the USAF aircrew member Increasing emphasis must be placed on the early diagnosis of those conditions that could result in sudden incapacitation Experience in aerospace medicine us limited to a younger more healthy population than that found in a hospital The significance of several electrocardiographic findings usually associated with disease in a sick population is not necessarily of the same importance in the Air Force patient population Four conditions that were considered representative of significant organic heart disease are considered These are electrocardiographic repolarization changes cardiac arrhythmias acquired bundle branch block and aortic valvular insufficiency
Author

N72 14102* Institute of Aviation Medicine Fuerstenfeldbruck (West Germany)

CARDIOLOGIC FINDINGS AS CAUSE FOR GROUNDING

H W Kirchhoff and A Dietz *In* AGARD Clinical Causes for Grounding Nov 1971 3 p (See N72 14090 05 05)

Avail NTIS

The routine cardiologic program performed at the Institute of Aviation Medicine of the German Air Force to determine fitness for military flying duty is described It is comprised of an overall clinical examination an electrocardiogram taken at rest and the so called master two step test If required the physician may order additional electrocardiographic mechanocardiographic and functional medical tests Armed forces regulation serves as the criterion for the final assessment and lists all findings which preclude or render questionable flying duty Author

N72 14103* Institute of Aviation Medicine Fuerstenfeldbruck (West Germany)

NEW FINDINGS CONCERNING THE IMPORTANCE OF ARRHYTHMIAS

A Dietz *In* AGARD Clinical Causes for Grounding Nov 1971 6 p (See N72 14090 05 05)

Avail NTIS

Long term electrocardiograms (EKG s) are recorded at the Institute of Aviation Medicine of the German Air Force for any subject showing rhythmic cardiac disturbances Long term registration is superior to routine EKG s with respect to recording arrhythmias The advantages and techniques of long term EKG s are considered Author

N72 14104* Institute of Aviation Medicine Fuerstenfeldbruck (West Germany)

INCIDENCE OF CORONARY RISK FACTORS IN PILOTS OF THE BUNDESWEHR

Klaus Jung *In* AGARD Clinical Causes for Grounding Nov 1971 10 p (See N72 14090 05 05)

Avail NTIS

A group of 1000 pilots of different types of aircraft were examined with respect to distribution of various parameters which in extreme cases constituted coronary risk factors Cigarette consumption serum cholesterol level systolic and diastolic blood pressure physical activity body weight vital capacity fasting blood sugar level autonmesia and family predisposition were studied in detail For the sum of risk factors the distributions were considered for total group separate age groups pilots grouped according to types of aircraft flown (total and in separate age groups) and for pilots under 30 years of age grouped according to aircraft flown and training status Coronary stress is barely increased compared to a normal population Prop pilots are at least coronarily jeopardized to the same extent as jet pilots This is particularly true for older age groups The greatest increment of psychophysical stress effects on the coronary system occurs between the start of training and the first flying experience independent of the aircraft type flown
Author

N72 14105* Office of the Surgeon General (Air Force) Washington D C

SUSPENSIONS OF PILOTS AND NAVIGATORS FROM FLYING STATUS FOR MEDICAL REASONS IN THE UNITED STATES AIR FORCE, 1969

Robert A Farmer and Howard R Unger *In* AGARD Clinical Causes for Grounding Nov 1971 7 p (See N72 14090 05 05)

Avail NTIS

The age distribution causes numbers and diagnostic categories of medical suspensions of flying personnel in the U S Air Force which occurred in 1969 are discussed Identification of preventive and clinical medical practices and policies which may prevent or remove the medical cause of the suspension are made possible by the study Author

N72 14106* Royal Air Force Central Medical Establishment, London (England)

CURRENT NASAL AND AURAL INDICATIONS FOR GROUNDING

P F King *In* AGARD Clinical Causes for Grounding Nov 1971 6 p refs (See N72 14090 05 05)

Avail NTIS

The current indications for aircrew grounding due to nasal and aural disorders are described The importance of careful preliminary selection is emphasized The decreasing incidence of nasal infection was noted together with the increasing part played by nasal allergy The question of chronic bronchitis bronchiectasis and asthma which complicate nasal disease is discussed Of the commoner aural lesions otosclerosis as a cause of permanent grounding and the effect of stapedectomy are considered Chronic otitis media and the indications for grounding compared with those permitting continued flying are examined The relative and absolute indications for grounding in cases of chronic otitic barotrauma are discussed Perceptive deafness and labyrinthine causes of vertigo and their influence on fitness to fly are also described Author

N72 14107* Institute of Aviation Medicine Fliegehorst (West Germany)

CAUSES FOR PERMANENT GROUNDING AND REJECTION IN THE ENT DEPARTMENT OF THE INSTITUTE OF AVIATION MEDICINE OF THE GERMAN AIR FORCE

G Froehlich *In* AGARD Clinical Causes for Grounding Nov 1971 3 p (See N72 14090 05 05)

Avail NTIS

From 1959 to 1968 there were 22 800 periodic reexaminations of pilots and student pilots of the German armed forces 55 or 0 24% of these were permanently grounded In this group 38 were students with marked high tone hearing losses due to impact noise at the shooting range The remainder suffered from recurrent barotitis (3) vestibular disease (3) chronic sinusitis (2) allergic rhinitis (1) and Meniere s disease (1) The rates for permanent rejections of applicants for flight training decreased considerably after the adoption of more flexible hearing standards in 1966 Again most of the rejections were due to considerable hearing losses caused by impact noise In a sample of 2000 initial examinations the rejection rates were highest among young Army officers and Army NCO s and lowest among Air Force applicants The main causes for temporary grounding of applicants were sinusitis marked septal deviations catarrhal otitis media and chronic tonsillitis All these cases were accepted for flying training if there was full recovery after proper treatment Cases with simple mastoidectomy and small atrophic scars of the tympanic membrane are acceptable as well as cases with tympanoplasty type 1 provided the ears are functionally normal Author

N72 14108* Institute of Aviation Medicine Fuerstenfeldbruck (West Germany)

OPHTHALMOLOGICAL CAUSES FOR GROUNDING A 10 YEARS REPORT

Dietrich Kurschner *In* AGARD Clinical Causes for Grounding Nov 1971 4 p (See N72 14090 05 05)

Avail NTIS

From 1959 to 1969 51 pilots in the German Air Force

were permanently grounded on the basis of ophthalmological diagnoses The total number of examinations made was 24 396 These 51 cases were classified according to diagnosis They were as follows anomalies of refraction (28) anomalies of color sense (3) anomalies of accommodation (1) anomalies of stereopsis (1) blepharitis (1) anomalies of pupillary function (1) cataract (2) aphakia (2) retinal diseases including 2 retinal detachments (7) and glaucoma (5) Author

N72-14109# Canadian Armed Forces Inst of Environmental Medicine. Toronto (Ontario)
DIABETES MELLITUS IN FLYING PERSONNEL
W J C Stevenson *In* AGARD Clinical Causes for Grounding Nov 1971 6 p refs (See N72 14090 05 05)
Avail NTIS

The Central Aircrew Medical Board at the Canadian Forces Institute of Environmental Medicine assessed fifteen aircrew members in the past ten years who were referred because of abnormal glucose tolerance observed following incidental findings of reducing substances in the urine at time of routine urinalysis The clinical findings, investigation procedures, and followup are discussed for two of the fifteen cases These were referred because evidence suggested possible adult onset of diabetes mellitus Four of the fifteen were permanently grounded the remainder were returned to flight duties One individual case was followed for ten years without development of the overt disease or any associated symptomatology Reference is made to Canadian Air Force policy in dealing with cases of diabetes mellitus in aircrew members Author

N72-14110# Royal Air Force Farnborough (England)
PSYCHIATRIC CASUALTIES AMONG AIRCREW OF THE ROYAL AIR FORCE OF GREAT BRITAIN FOR TEN YEARS 1959 TO 1968
P J OConnor *In* AGARD Clinical Causes for Grounding Nov 1971 4 p (See N72 14090 05 05)
Avail NTIS

The causes of 262 permanent groundings for psychiatric illness in the Royal Air Force are discussed in detail for the ten years 1959 to 1968 One quarter of the cases were grounded for psychotic illness and three quarters for neuroses and personality disorders Psychiatric wastage accounts for 10% of the total medical wastage Author

N72-14111# Institute of Aviation Medicine Fliegerhorst (West Germany)
PSYCHOLOGICAL CAUSES FOR GROUNDING WITH SPECIAL CONSIDERATION OF PSYCHOSOMATIC SYNDROMES AND FEAR OF FLYING
K Gerbert and H P Goorres *In* AGARD Clinical Causes for Grounding Nov 1971 7 p refs (See N72 14090 05 05)
Avail NTIS

One third of all groundings of pilots in the German Air Force within the last ten years was due to psychological reasons This number is surprisingly high considering the fact that the aviation psychologists do not routinely see every pilot It is the task of the psychologists to select potential washouts and to investigate the causes of psychophysical performance decrements Anxiety and fear are analyzed as flying stress reactions Author

N72-14112# Centre Principal d Expertises Medicales du Personnel Navigant Paris (France)
FLIGHT GROUNDING FOR PSYCHOLOGICAL AND PSYCHIATRIC REASONS [LES INTERDICTIONS DE VOL POUR RAISONS PSYCHOLOGIQUES ET PSYCHIATRIQUES]
Rene Gelly *In* AGARD Clinical Causes for Grounding Nov 1971 6 p In FRENCH (See N72-14090 05 05)
Avail NTIS

Two sorts of psychopathology exist among aviators The first is general independent of the subject s professional life and is associated with other aspects of his life The second is a specific psychopathology which is due to the difficulties of aeronautic adaptation and which occurs almost uniquely in the domain of the subject s professional life Observations made for French Air Force personnel in 1969 were collected and divided into classes in order to study the distinction implied in diagnosis prediction treatment and deciding flight aptitude in psychological cases The classes considered were the general psychiatry of flying personnel and their specific psychopathology Information on diagnostics aptitude decisions and development over a year of observation was also collected Therapy and medical administrative suggestions are presented for the two pathologies Transl by K P D

N72-19119# Advisory Group for Aerospace Research and Development. Paris (France)
LINEAR ACCELERATION OF IMPACT TYPE
26 Feb 1971 436 p refs In ENGLISH and FRENCH Presented at the Aerospace Med Panel Specialist Meeting. Oporto. Portugal. 23-26 Jun 1971
(AGARD CP-88-71) Avail NTIS HC $6 00/MF $0 95

Recent aviation and automobile accidents are reviewed in an effort to reduce the human injury The biodynamics physiology, pathology. and clinical aspects of linear acceleration impact are discussed For individual titles. see N72 19120 through N72 19163

N72-19120# Royal Air Force. Farnborough (England)
TECHNICAL EVALUATION OF THE AEROSPACE MEDICAL PANEL SPECIALISTS MEETING ON LINEAR ACCELERATION (IMPACT TYPE)
D H Glaister *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 4 p (See N72 19119 10-05)
Avail NTIS HC $6 00/MF $0 95

Crash injury research is discussed, including biodynamics of impact, injury mechanisms and pathology, and techniques for impact attenuation Impact forces related to seat ejection, facilities for impact studies, impact protection (restraint system), and head protection devices are considered Recommendations for additional research are presented for crashworthiness, standardization, head and neck protection, ejection injury to the spine, and soft tissue injury mechanisms J A M

N72-19121# Army Aeromedical Research Lab, Fort Rucker, Ala
SYMPOSIUM ON LINEAR ACCELERATION OF IMPACT TYPE INTRODUCTORY REMARKS
Edward J Baldes *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 5 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

Biodynamic and bioengineering applications to operational problems in the interface of man machine relationships are reviewed Safety principles are discussed for reducing injuries Data are presented on accidents in aircraft training programs and on highways Author

N72-19122# Laboratoire UTAC Montlhery (France)
ECONOMIC PROCEDURES FOR SIMULATING THE EFFECTS OF LINEAR COLLISIONS IN VIEW OF STUDIES OF RESTRAINING DEVICES FOR THE PROTECTION OF AUTOMOBILE OCCUPANTS [PROCEDES ECONOMIQUES PUR SIMULER LES EFFETS DE COLLISIONS LINEAIRES EN VUE DE L'ETUDE DES DISPOSITIFS DE RETENUE OU DE LA PROTECTION DE OCCUPANTS D'UN VEHICULE AUTOMOBILE]
E Chapoux and H LeGuen *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 16 p In FRENCH (See N72 19119 10-05)
Avail NTIS HC $6 00/MF $0 95

An apparatus was designed and perfected for collision studies, which involves stopping of passenger movement The equipment described is being used in many European laboratories and provides many advantages at a minimal cost price
Transl by K P D

N72-19123# Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
AIRCRAFT ACCIDENT INJURIES AND AIRCRAFT ACCIDENT RECONSTRUCTION
S Krefft *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 11 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

The development and mechanics of injuries to aircraft passengers are examined The reconstructive conclusions with respect to the sequence of events, that can be drawn from the type, appearance, location, extent, and severity of the external and internal injuries sustained by the crash victims are discussed Investigations are used to illustrate that owing to the injuries suffered in an aircraft accident the crash victims can bear silent witness and not only provide important clues but solid evidence permitting a reconstruction of the sequence of events. Author

N72-19124# Royal Air Force Inst of Pathology and Tropical Medicine, Aylesbury (England)
HISTOPATHOLOGICAL RESPONSES TO DECELERATION
J K Mason *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 6 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

Personal observations of 340 fatal aircraft accidents are used to study simple confirmation of lacerations to victims The physical changes are described with reference to quantitation and differential diagnosis from natural disease The significance of pulmonary tissue embolism is emphasized Author

N72-19125# Michigan Univ, Ann Arbor Inst of Science and Technology
MAN'S SURVIVABILITY OF EXTREME FORCES IN FREE FALL IMPACT
Richard G Snyder *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 13 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

Exposure to extreme forces greater than experimentally tolerable were studied through human accidental or suicidal free-falls Examples selected from nearly 30,000 free-fall cases illustrate the range of injury and fatality limits found under various conditions Terminal velocity free-falls 53 64 m/sec (120 mph) without benefit of parachute were survived by Soviet, French, United Kingdom, and U S pilots and paratroopers under emergency ejection or evacuation conditions Biophysical biomechanical, and biomedical variables are discussed Results indicate that there is a complex balance between factors of magnitude, calculated rate of onset and event duration, body axis orientation, force distribution, and properties of the impacted surface Author

N72-19126# Association Peugeot-Renault, la Garenne-Colombes (France) Lab de Physiologie et de Biomecanique
COMPARISON OF THE EFFECTIVENESS OF TWO PASSIVE RESTRAINT SYSTEMS [EFFICACITE COMPAREE DE DEUX SYSTEMES DE RETENUE PASSIVE]
Claude Tarriere *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 13 p refs In FRENCH (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

Safety belts are discussed in regard to the optimization of webbing rigidity and the utilization of shock absorbers at chest level Performance level is compared to that of inflatable bags Completely passive, automatic belts are considered Experimental data are presented in terms of improving global efficacy, various highway accident types, and the cost/efficiency ratio
Transl by K P D

N72-19127# National Institutes of Health Bethesda Md National Inst of Neurological Diseases and Stroke
PROTECTION OF THE BRAIN FROM INJURY DURING IMPACT: EXPERIMENTAL STUDIES IN THE BIOMECHANICS OF HEAD INJURY
Ayub K Ominaya and Arthur E Hirsch (Natl Highway Traffic Safety Admin) *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 19 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

Experimental data on head injury are summarized in three subhuman primate species undergoing controlled direct head impact and indirect impulsive head loading (whiplash) Testing of Holbourn's rotational hypothesis and the translation/cavitation hypothesis revealed discrepancies Data are presented to show that a combination of heat rotation and skull distortion mechanisms are most injurious for brain damage during both direct and indirect impact Current mathematical models with simultaneous experimental testing in development are reviewed Author

N72-19128# Rochester Univ, N Y School of Medicine
BIODYNAMICS OF SPORTS INJURIES
John D States *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 6 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

Helmets and restraint systems used in automobile racing, modified football shoe cleats, and release ski bindings have reduced the injury risks in these sports Knowlege of human injury tolerance was gained through the study of sports accidents, particularly the determination of injury mechanisms Injury tolerance data determined in the laboratory was also useful in designing sports safety equipment Author

N72-19129# Army Board for Aviation Accident Research, Fort Rucker, Ala
ANALYSIS OF US ARMY HELICOPTER ACCIDENTS TO DEFINE IMPACT INJURY PROBLEMS
Joseph L Haley, Jr *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 13 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

An overall view of the occupant injury experience in U S Army helicopters from January 1967 through December 1969 is presented These data show that 40 percent of all occupant fatalities occurred in survivable accidents This percentage shows the need for further improvement of helicopter crashworthiness The statistics further indicated that fire was the single largest fatality cause with head injuries next in rank A group of severe but survivable helicopter accidents of the same time period was studied The study included three types of Army helicopters Study results indicated that the problem of postcrash fire fatalities was more severe in the utility and cargo helicopters It was also shown that potentially hazardous displacement of the transmission and main rotor blades occurred in one of every three utility and cargo helicopter accidents studied Further a roll about the long axis usually occurred At least one roll occurred in 2 of 3 light observation helicopter accidents, 5 of 8 utility helicopter accidents, and 1 of 2 cargo helicopter accidents The tendency to roll highlights the need to consider sideward occupant restraint and transmission/rotor blade moorings in these helicopters Author

N72-19130# Birmingham Univ (England) Dept of Transportation
AN ASSESSMENT OF ACTIVE AND PASSIVE RESTRAINTS IN SERIOUS INJURY EUROPEAN CAR OCCUPANT COLLISIONS
G Murray Mackay *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 12 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

A field study of road accidents numbering 105 vehicles selected from the severe and fatal injury end of the injury spectrum are examined The incidence of various crash configurations is outlined, together with the objects struck, and the rate with which the passenger compartment is penetrated The relative frequencies of side impacts, and multiple and complex collisions are described Each collision is examined in terms of the reduction in injuries to front seat occupants which might be obtained if an air bag was present In a similar manner each collision is examined to assess the benefit if a lap diagonal seat belt were worn An overall judgement is therefore obtained

on the relative benefits obtainable from airbags and belts. Belts are shown to be superior because they provide protection in a greater range of collision types. If a belt wear rate exceeding some 63% for drivers and 85% for front passengers were obtained then belts provide greater benefits than airbags. The importance of intrusion into the passenger compartment, especially in fatal collisions is emphasized as a restriction on restraint effectiveness in present day European car designs. Author

N72-19131# Naval Aerospace Medical Research Lab., New Orleans, La.
HUMAN DYNAMIC RESPONSE TO MINUS GX IMPACT ACCELERATION
Channing L. Ewing and Daniel J. Thomas *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 12 p refs (See N72-19119 10-05)
Avail: NTIS HC $6.00/MF $0.95

The purposes of the study were fourfold (1) to measure precisely the complete input acceleration to the head and neck measured at the first thoracic vertebra, (2) to measure precisely the dynamic response of the head and neck to the input acceleration, (3) to develop a method of obtaining the data in such a form that automatic data processing may be used and (4) to develop and validate a general method for the experimental measurement of the bioengineering characteristics of the human body with such precision, accuracy, and repeatability that a mathematical model of the human dynamic response to impact acceleration can be constructed. Author

N72-19132# Naval Aerospace Medical Research Lab., New Orleans, La.
THEORETICAL MECHANICS FOR EXPRESSING IMPACT ACCELERATIVE RESPONSE OF HUMAN BEINGS
Daniel J. Thomas and Channing L. Ewing *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 7 p refs (See N72-19119 10-05)
Avail: NTIS HC $6.00/MF $0.95

The theoretical requirements for expressing the kinematics of human impact acceleration experimentation are presented. Two basic coordinate systems for expression of the kinematic information are identified as (1) the body reference frame, defined in terms of the experimental subject's anatomy, (2) the laboratory reference frame. A general set of rules for deriving these coordinate systems is described. Variables and parameters are defined in terms of the general set of rules. The resulting descriptions are compared with definitions for use in prolonged acceleration. Author

N72-19133# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio. Biodynamics and Bionics Div.
BIODYNAMIC MODELS AND THEIR APPLICATIONS
Henning E. vonGierke *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 18 p refs (See N72-19119 10-05)
Avail: NTIS HC $6.00/MF $0.95

Progress in modeling the mechanical response of man exposed to various environmental forces is discussed. Starting with a mathematical description of the mechanical and physical characteristics of the integument, soft and hard tissue, the numerous approaches taken and the results obtained from modeling various integrated elements such as the human vertebral column under vibration and impact loads, the chest and respiratory system under vibratory and blast loads and of the whole body system for selected force input conditions and locations are reviewed. To derive a capability of modeling specific injury modes or experimentally observed probabilities of injury curves for various parenchymatous and hollow organs as a function of the force input variables, more detailed and specialized models are being used such as, for example, the lumped parameter, discrete parameter, and continuum mode of the spine or models considering nonlinear tissue behavior. The status and value of these models for studying the body's physical and physiological response, for understanding and predicting injury mechanisms and probability of injury, for scaling the results of animal experiments, and for applying the models in protection engineering, such as escape and restraint systems design, are demonstrated. There is need for further experimental, as well as theoretical work, in support of these practical biomedical and hardware requirements. Author

N72-19134# Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex.
THE BIODYNAMICS OF AIR BLAST
Clayton S. White, Robert K. Jones, Edward G. Damon, E. Royce Fletcher, and Donald R. Richmond *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 21 p refs Sponsored by DASA and AEC (See N72-19119 10-05)
Avail: NTIS HC $6.00/MF $0.95

After pointing out that accelerative and decelerative events are associated with the direct and indirect effects of exposure to blast-induced winds and pressure variations, some of the relevant biophysical parameters were selectively noted and discussed. These included the pressure-time relationship, species differences, ambient pressure effects, the significance of positional (orientational) and geometric (situational) factors as they influence the wave form, the pressure dose and the biologic response, and data bearing upon the etiology of blast injury. The consequences of pressure-induced violent implosion of the body wall and the significance of the associated variations in the internal gas and fluid pressures were described and emphasized, as were alternating phases of forced hemorrhage and arterial air embolization, fibrin thrombi, coagulation anomalies, and renal, cardiac and pulmonary sequelae. Tentative biomedical criteria consistent with recent interspecies scaling and modeling studies for assessing primary blast hazards were presented. Author

N72-19135# Department of Transportation, Washington, D.C. Natl. Highway Traffic Safety Administration.
LETHAL EFFECTS ON MAN OF UNDERWATER DETONATION OF A FIRECRACKER
Arthur E. Hirsch and Ayub K. Ommaya (NIH) *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 5 p refs (See N72-19119 10-05)
Avail: NTIS HC $6.00/MF $0.95

A firecracker exploded in contact with the skin within six inches of the skull base in a young man while he was swimming underwater. The resultant severe head injury and death appeared to be directly related to this underwater explosion. Reconstruction of the mechanics of this injury indicate that when the head is subjected to impact energies between 440 to 1800 in-lb and impact impulse between 1.8 to 3.5 lb-sec., both skull fracture and brain injury can occur. Author

N72-19136# Institutes fuer Wehrmedizin und Hygiene, Koblenz (West Germany).
HUMAN STRESS LOADS INDUCED THROUGH SIMULATED PRESSURES ON UNDERGROUND SHELTERS
G. Kleinhanss and H. Dupuis (Technischon Univ., Munich) *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 9 p refs (See N72-19119 10-05)
Avail: NTIS HC $6.00/MF $0.95

Within the constraints of a simulated nuclear strike, the human stress loads to be expected were assessed through physical measurements taken on dummies placed in an underground shelter. Results verified that under the given conditions, exposure to shock would not cause detrimental effects to the health or a reduction in efficiency, due to physical factors, of operators manning control desks in the underground shelter. It is pointed out that results obtained on dummies may be applied analogously to man only to a limited extent since no dummies showing human physiological and dynamic behavior were available. The assessment results apply only to the movement vectors observed during this test on shelter floor and walls. Conceivably other vector variations may produce fundamentally different results. The measuring data related to three different seating arrangements indicate technical possibilities for shock reduction. Author

N72-19137# Army Aeromedical Research Lab., Fort Rucker, Ala. Bioengineering and Evaluation Div.

PARACHUTING IMPACT INJURIES AT HIGH DROP ZONE ELEVATIONS: ENVIRONMENTAL EFFECTS

Stanley C. Knapp and George R. McCahan, Jr. *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 9 p refs (See N72-19119 10-05)

Avail: NTIS HC $6.00/MF $0.95

A review of parachuting injuries that are directly related to accelerative forces and impact is presented. The available and valid injury prediction statistics for a wide variety of parachuting activities is discussed. The environmental effects of wind shear, wind velocity, wind thermals, density altitude, terrain and topography, increased rates of descent, and temperature variations upon injury morbidity are analyzed. These effects were determined during experiments at 6,000 and 10,000 feet drop zone altitudes using the 32 feet parabolic apex vented-static line deployed parachute. Injury rates were four times greater than those expected or experienced at sea level elevations. The conclusions and recommendations will be of practical value in the training and outfitting of parachutists for jumps into high elevation drop zones. Author

N72-19138# Italian Air Force Aerospace Medical Center, Rome.

BEHAVIOUR OF SOME SERUM ENZYME ACTIVITIES IN MAN, AFTER CRASH ACCIDENTS, CAUSING MASSIVE INJURIES

G. Paolucci, G. Blundo, and A. Balla *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 5 p refs (See N72-19119 10-05)

Avail: NTIS HC $6.00/MF $0.95

Observations were made of blood serum enzyme activities in an effort to verify the fact that such activity causes massive injuries and fractures to the human body. Several people involved in severe road accidents were observed for activities of the following enzymes: (1) Glutamic oxalacetic transaminase (GOT), (2) Glutamic pyruvic transaminase (GPT), (3) Lactate and Malate dehydrogenase (LDP MHD), (4) Adalose (ALD), (5) Alkaline phosphates (ALKP), (6) Acid phosphate (AcP). Results show some enzyme activities increase in the most severely injured subjects and that a correlation exists between some enzyme activities and body damage. Results also indicate the possibility of evaluating the degree of body damage from certain enzyme activities and that some enzymes analyses, especially GOT, may be useful for diagnosis and medico-legal judgements. Author

N72-19139# Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio.

THE DYNAMIC BIOMECHANICAL NATURE OF SPINAL FRACTURES AND ARTICULAR FACET DERANGEMENT

Leon E. Kazarian, Dale D. Boyd and Henning E. vonGierke *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 25 p refs (See N72-19119 10-05)

(AMRL-TR-71-17) Avail: NTIS HC $6.00/MF $0.95

Through the application of appropriate scaling laws animal experiments, particularly on primates, are shown to be of value in explaining hard tissue injury mechanisms and individual organ injury potential in man exposed to impact forces. In support of this approach rhesus monkeys were anesthetized, radiographed, positioned in an impact carriage, restrained by lap belt, torso harness, and limb retention straps, and exposed to +Gz seated rectangular acceleration time histories from predetermined drop heights. Shortly following impact all primates were radiographed, killed, and a necropsy performed. Attempts were made by means of an injury classification system to determine injury potential as a function of plateau acceleration and pulse duration for the spinal column. Type, frequency, and severity of vertebral body centrum fractures along with injury to the vertebral appendages were classified. Vertebral articular facets apophyseal joints disorders and derangements proved difficult to identify radiographically due to poor X-ray film resolution, overlying soft tissue, and bony margin shadows. Necropsy demonstrated a large percentage of primates exhibited this type of lesion. Injury probabilities for the vertebral column established by radiographic and gross necropsy examination supplement and explain available knowledge on spinal injury mechanisms observed in the rhesus monkey. Author

N72-19140# Strathclyde Univ., Glasgow (Scotland). Bioengineering Unit.

THE MECHANICAL AND STRUCTURAL CHARACTERISTICS OF CONNECTIVE TISSUE

Bryan Finlay, John H. Evans, James F. North, Tom Gibson, and Robert M. Kenedi *In* AGARD Linear Acceleration of Impact Type 26 Feb. 1971 10 p refs (See N72-19119 10-05)

Avail: NTIS HC $6.00/MF $0.95

A range of test procedures is described in detail and typical data are given for human skin to illustrate the rate sensitive non-linearities that may be encountered with these materials. Criteria used to assess the failure of a tissue are considered on the basis of impairment of physiological function. The normal structure of skin and its response to stress is illustrated by the use of the scanning electron microscope and the construction of a tendon model is described before finally assessing the whole process of tissue modelling. Author

N72-19141# Hughes Tool Co., Culver City, Calif. Aircraft Div.

DESIGNING HELICOPTERS FOR IMPROVED CRASH SURVIVABILITY c02

Henry G. Smith *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 14 p refs (See N72-19119 10-05)

Avail: NTIS HC $6.00/MF $0.95

The fundamental theory for providing attenuation of the crash impact is reviewed, with emphasis upon understanding the relationship of the fundamental parameters of the problem. Based upon operating statistical data in regard to potentially survivable crashes, along with engineering studies of any new helicopter design, design objectives can be established for the level of crash protection to be provided for the occupants. In problems of this type, a tradeoff always exists between size and weight penalties incurred for crash survivability versus the value of that same amount of size or weight for performance, payload, armor, or armament. Methods of attenuating or absorbing the crash impact in a gradual manner are the key to the provision of high crash protection levels while imposing minimum weight penalties upon the helicopter. Operating experience confirms that improved helicopter crash survivability can actually be obtained in a military operational environment. In addition to the improvement of survivability, improved morale of the crew members was a side benefit. The current trends of crash protection for new helicopter designs are discussed with implications of further improvement from the crash survivability standpoint in future helicopters. Author

N72-19142# Cornell Aeronautical Lab., Inc., Buffalo, N.Y.

AUTOMOBILE STRUCTURAL CRASHWORTHINESS CONCEPTS FOR CRASH PROTECTION

Patrick M. Miller *In* AGARD Linear Acceleration of Impact Type 26 Jun. 1971 16 p refs (See N72-19119 10-05)

(Contract DOT-FH-11-6918)

Avail: NTIS HC $6.00/MF $0.95

A series of full scale automobile crash tests were conducted to determine the structural crashworthiness performance of conventional automobiles and to evaluate the performance of structural concepts designed to provide protection during frontal and lateral impacts with fixed objects. Conditions believed to be representative of severe single vehicle accidents, where automobiles impact narrow obstacles, were developed and used in the study. The objectives of the structural modifications were to produce a more uniform energy absorption, i.e., more uniform decelerations near 40 g's and 20 g's, respectively, for frontal and lateral collisions. The frontal structural modifications considered both front and rear engine vehicle designs and were evaluated under impacts with a rigid pole barrier where the collision speeds ranged from 35 MPH to 63 MPH. These structural modifications were designed so that the entire distance in front of the passenger compartment could be used for energy

absorption The results demonstrated that the modifications when coupled with this restraint system provide for a force limiting system on the occupant for this range of impact conditions Author

N72-19143# Wright Co Kettering, Ohio
ARMOR MATERIALS FOR LIFE SUPPORT
Robert Fred Rolsten, Joseph G Dunleavy, and Edward G Budine *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 14 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

A historical review of armor personnel protective devices is presented together with the philosophy of the use/disuse of armor The current levels of protection, armor designs and materials state-of-the-art are discussed Author

N72-19144# Deputy Inspector General for Inspection and Safety (Air Force) Norton AFB, Calif
OPERATIONAL ASPECTS OF FORCES ON MAN DURING EJECTION EXTRACTION ESCAPE IN THE US AIR FORCE, 1 JANUARY 1968 31 DECEMBER 1970
Robert H Shannon *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

A study of 468 ejections in the United States Air Force (USAF) reported during the period 1 January 1968 to December 1970 disclosed that one in nine crew members involved received major or fatal injuries as a result of forces encountered from system initiation to parachute opening In 49 cases the injuries received were classified as major (nonfatal) and three crew members were fatally injured The majority of the major injuries were attributed to the initial forces of ejection and were primarily compression fractures of the vertebral column These injuries continue to occur with consistent frequency in spite of the fact that the maximum accelerations of the catapults in use today are well below human tolerances The major factors which influence the incidence of ejection force injuries are the type catapult used, ejection posture, and age of the individual involved Of the three, ejection posture appears to be the single most critical factor The correlation of the individual's weight by type catapult was not remarkable The frequency of injuries attributed to Q-forces showed a significant increase over previous studies of USAF ejection escape experience Although the incidence of high speed ejections has increased only slightly Q-force injuries occurred in 4 percent of all nonfatal ejections and accounted for 12 percent of the total major injuries Author

N72-19145# Loughborough Univ of Technology (England) Dept Ergonomics and Cybernetics
MEASUREMENT OF HUMAN RESPONSES DURING IMPACT
J Sandover *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 12 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

In response to a need for information on the dynamic properties of man when using ejection seats, equipment has been developed to simulate the transient acceleration of ejection The equipment, and the data acquisition and processing systems, are described The apparatus was used for mechanical impedance studies and performs adequately up to 30 Hz The present experimental program is designed to provide information on the variations of mechanical response of individual subjects and between subjects in a relatively restrictive experiment (e g hard seat upright posture low acceleration levels) The experiments so far indicate the existence of a series resonance at 9 to 10 Hz The use of mechanical impedance techniques leads to accurate measurement of mechanical response at the input to the body but does not offer a great deal of evidence for the postulation of detailed models For this reason internal and external transmissibility measurements are advocated Some preliminary transmissibility measurements are recorded Considered of the literature and the transmissibility measurements indicates deficiencies in many models of the body and the need for a simple direct approach Author

N72-19146# Centre d Essais en Vol, Bretigny sur-Orge (France) Lab de Medecine Aerospatiale
EJECTION ACCELERATION: PHYSIOLOGICAL EFFECTS, TOLERANCE [ACCELERATIONS A L'EJECTION: MOYENS D'ETUDE EFFETS PHYSIOLOGIQUES, TOLERANCE]
R Auffret, H Seris, J Demange, and R P Delahaye *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 6 p refs In FRENCH (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

The physiological effects of acceleration and ejection on man are studied with the aid of a centrifuge Major efforts were made to establish human tolerance to different acceleration stresses and determine the occurence of lumbosacral spinal injuries, particularly intervertebral disks The characteristics and performance of the centrifuge are included Transl by E H W

N72-19147# Royal Aircraft Establishment, Farnborough (England) Human Engineering Div
BLAST TESTING AIRCREW ESCAPE EQUIPMENT INCLUDING AN ACCOUNT OF A NEW TRANSONIC TEST FACILITY
J M Rayne *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

The design of a facility and its performance in determining the effectiveness of aircrew equipment to air blasts up to Mach 1 3 are discussed In this device the air speed decay profile is programmed and can be made to simulate a range of post ejection conditions from sea level to altitude Tests on a protective helmet demonstrate that it will probably be practicable to give head protection up to about 700 kt at sea level However, failures of the visor which have occurred, show that explosive disintegration of the whole helmet follows at air speeds from 600 kt upwards Helmet and visor failures usually occur within 100 msec of exposure and the blast effect can be regarded as an impact In testing helmets therefore, the total duration of exposure to severe blast does not appear to be important On the other hand, fabric is destroyed by the effects of flutter and the extent of damage seems to be time dependent Therefore, in testing fabric protective equipment the shape of the air flow decay curve may well be important Author

N72-19148# Centre d Essais en Vol Bretigny-sur-Orge (France)
RADIOLOGICAL STUDY OF SPINAL INJURIES TO PILOTS UNDERGOING SUDDEN EJECTION [ETUDE RADIOLOGIQUE DES LESIONS DU RACHIS CHEZ LES PILOTES AYANT SUBI UNE EJECTION]
R P Delahaye, H Seris, R Auffret, G Gueffier, and P J Metges *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p refs In FRENCH (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

Spinal injuries to pilots caused by sudden ejection are studied radiologically The study was made in an attempt to determine the exact traumatic injury, the vertebrae involved the localization, and the type of fractures The fractures caused by the propulsion of the ejection seat are also studied It was determined that the ejection seat usually caused injuries to the 6th, 7th and 8th vertebrae it was also determined that the position of the pilot upon ejection contributes to spinal injuries Transl by E H W

N72-19149# Hellenic Air Force General Hospital Athens (Greece) Orthopaedic Dept
SOME OBSERVATIONS ON COMPRESSION FRACTURES OF THE SPINE IN EJECTED GREEK PILOTS
Pan P Symeonides *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 3 p refs (See N72-19119 10-05)
Avail NTIS HC $6 00/MF $0 95

The causes of compression fractures in Greek pilots during the decade 1960-1969 were investigated Resumption of duties by pilots with such fractures was studied It was found that 18 percent of the ejected pilots sustained compression fractures of the spine All fractures occurred during ejection and were located at the dorsolumbar region of the spine (T10 to L3) There was

sufficient evidence that excessive tightening of the ejection seat belts (shoulder-buttocks) produces a permanent flexion of the spine which thus becomes more vulnerable during ejection If the wedging of a vertebra following a fracture does not exceed 1/3 of the height of the vertebral body and the symptoms are mild enough, the pilot may return to the active service as jet pilot If wedging is greater than 1/3, he should not resume his previous duties either as jet or helicopter pilot because the created local kyphosis of the spine renders the neighboring vertebrae more vulnerable. Author

N72-19150# Civil Aeromedical Inst., Oklahoma City, Okla Protection and Survival Lab
DESIGN CONSIDERATIONS FOR IMPACT TEST FACILITIES
Richard F Chandler *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 10 p refs (See N72-19119 10-05)
Avail NTIS HC $6.00/MF $0.95

With the advent of World War 2 pilot shortage necessitated scientific investigation of the causes of crash injury These early investigations made use of a variety of test facilities, including swing seats, acceleration towers, drop towers, acceleration tracks, and deceleration tracks The facilities served as a basis for similar devices in use today The purpose of these facilities is to produce a controlled impact representative of an actual crash Good simulation of the magnitude of acceleration changes is possible on these facilities, but none provide exact replication of the change in acceleration direction which is experienced in a crash Author

N72-19151# Royal Air Force Inst of Aviation Medicine, Farnborough (England)
A LINEAR DECELERATION TRACK
A F Giles *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 9 p (See N72-19119 10-05)
Avail NTIS HC $6.00 MF $0.95

The linear decelerator is housed in a building 52 m (170 ft) long and has a track length of 46 m (150 ft) The 545 kg (1200 lb) test vehicle is capable of carrying a payload of 160 kg (350 lb) and is propelled by rubber bungee ropes It can attain a peak velocity of 23 metres/second (75 ft/sec) The arrester mechanism is capable of producing a peak vehicle deceleration of up to 50g and consists of a steel cable harness stretched across the track, each end being connected to the piston of a hydraulic cylinder When the vehicle displaces the cables, movement of the pistons squeezes hydraulic fluid from each cylinder through a metered orifice, resulting in a controlled deceleration force on the vehicle The profile shapes available are a half sine wave, a sine wave with a 50 millisecond plateau, a double peak, or a triple peak Gravity onset rates can be varied from 60g/second to 750g/second Author

N72-19152# Max-Planck-Institut fuer Arbeitsphysiologie, Dortmund (West Germany)
AN ELECTRO HYDRAULIC SYSTEM FOR SIMULATIONS OF COLLISIONS
W Lange *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 4 p (See N72-19119 10-05)
Avail NTIS HC $6.00/MF $0.95

Equipment is described which is used in simulations of automobile collisions The device consists mainly of a guided sled on which the cabin can be mounted forward, obliquely laterally, or backward The sled, which can be accelerated between 0 and 30 g, is piston powered and controlled by an electrohydraulic catapult Mechanical, hydraulic and electrical design features as well as the recording system are described Author

N72-19153# Fiat S.p.A., Turin (Italy)
FIAT CATAPULTS
E Franchini *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p refs (See N72-19119 10-05)
Avail NTIS HC $6.00/MF $0.95

An outline is drawn of several propulsion systems adopted to launch a car against an obstacle and the reasons are given why the catapult system was preferred This system allows the possibility of launching a car indoor, it is simple and of low cost and has a high operational flexibility A description is given of the low and medium speed impact catapult and of the new catapult for collisions at up to 80 km/h of cars up to 2000 weight The catapult design diagrams are given. The control and operation devices and the measuring instrumentation, are described The different types of test run with the catapult are illustrated They include (1) head-on collision against barrier at 90 degrees or at other angles of approach, (2) side impact against stationary car, (3) rear end collision, (4) wedging under stationary truck front, side or tail, (5) launching of car, raised clear of ground and placed transversally on the trolley to simulate the side skidding impact against barrier or pole (6) sudden braking of a complete car to study the behavior of dummies in their impact against passenger compartment interior, (7) sudden braking of a dolly, on which a dummy is installed to study seat belts (or other restraint) or the impact of driver against steering wheel Author

N72-19154# Motor Industry Research Association, Lindley (England)
THE MIRA VEHICLE IMPACT TEST FACILITY
T R Aston *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p (See N72-19119 10-05)
Avail NTIS HC $6.00 MF $0.95

Tests were conducted out of doors initially, but with the introduction of legislation a large number of certification and compliance tests became necessary and, mainly because of the unpredictable climate in the U.K., it was found necessary to build an indoor test rig On this test rig a linear induction motor is used as the prime mover and it is capable of accelerating vehicles of up to 10,000 lb in weight to any speed up to 30 mph Special provision was made for high speed cine photography and electronic instrumentation, and the entire test rig is automatically controlled In order to safeguard personnel a comprehensive safety interlock system was incorporated Author

N72-19155# National Bureau of Standards, Washington, D.C.
THE MATHEMATICS OF IMPACT, AND CRASH TESTS OF AIRPLANE AIRBAG RESTRAINT SYSTEMS
Carl C Clark *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p refs (See N72-19119 10-05)
Avail NTIS HC $6.00/MF $0.95

The r sub x, g sub y, and g sub z linear acceleration and r dot sub x, r dot sub y, and r dot sub z angular acceleration terminology (the latter representing radians/sec sq) is reviewed It is urged that the representation of human acceleration environments by accelerometers be filtered to be flat (with less than 0.5 db variation) in response from 0 to 240 Hertz and then attenuated above 240 Hz at 12 db per octave, in preference to the more common representation by ac accelerometers (flat from about 10 to 2000 Hertz) This latter representation often obscures biologically important accelerations in metal ringing spikes Illustrations are drawn from crash studies of airplane airbag restraint systems and from mathematical representations of passenger compartment loads for automobile crashes of various types Author

N72-19156# Michigan Univ, Ann Arbor
BIOMECHANICS OF RESTRAINT AND IMPACT ATTENUATION SYSTEMS
Verne L Roberts and James H McElhaney *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 9 p refs (See N72-19119 10-05)
Avail NTIS HC $6.00/MF $0.95

The methodology and results from research program concerning the protective aspects of passive restraint systems are provided The criteria which should be used in the evaluation of passive restraints are provided and the experimental and analytical tools to define restraint performance are discussed Research indicates that passive restraints can provide protection equal to that provided by belt systems and that a passive

restraint must be carefully integrated with the vehicle interior to provide optimum protection Author

N72-19157# Aerospace Medical Research Labs. Wright-Patterson AFB, Ohio
RESTRAINT DESIGN. LABORATORY TEST AND EVALUATION OF OPERATIONAL EFFECTIVENESS
James W Brinkley and John T Shaffer *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 7 p refs (See N72-19119 10-05)
Avail NTIS HC $6.00/MF $0.95

Methods used to design contemporary personal flight equipment, such as restraint systems and ejection seat cushions, are presented. Emphasis is placed on the acceleration protection aspects of the design. Both analytical modeling and experimental determination of material characteristics are discussed. Experimental results of laboratory impact test evaluations of three items of personal equipment using human subjects are presented. These experiments include an evaluation of three operational restraint harnesses at -g sub x acceleration levels up to 15 g, a study of the acceleration transmission characteristics of ejection seat cushions, and work completed in the study of acceleration protection provided by rapidly deployed air bag restraint systems. The implications of the experimental findings are discussed and related to operational experience Author

N72-19158# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).
A CASE FOR THE NEGATIVE-G STRAP
R C Reade *In* AGARD Linear Acceleration of Impact Type refs (See N72-19119 10-05)
Avail NTIS HC $6.00/MF $0.95

The addition of a negative-g strap is proposed in order to overcome some of the inadequacies of current restraint harnesses. The effects of aerobatics, vertical vibration, and crash impact on a harness are detailed and the way in which the negative-g strap improves restraint is described. The advantages and disadvantages of negative-g straps in harnesses are discussed, and details of construction, location, and fitting are presented Author

N72-19159# Max-Planck-Institut fuer Arbeitsphysiologie, Dortmund (West Germany)
SEVERE FRONTAL COLLISIONS AND RESULTING INJURIES WITH AND WITHOUT RESTRAINING DEVICES
W Lange *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 10 p refs (See N72-19119 10-05)
Avail NTIS HC $6.00/MF $0.95

The results of simulated frontal collisions are briefly described. Types and magnitudes of injuries sustained by cadavers depended on (1) whether or not they were restrained by safety belts, (2) type and stiffness of belts, (3) absence or presence of steering assembly and instrument panel and (4) interactions between body, harness and structures in the driver's space. Two pilot studies with air bags yielded conflicting results Author

N72-19160# Royal Air Force Inst. of Aviation Medicine, Farnborough (England)
PROTECTION OF THE HEAD
J A Gillies *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 3 p (See N72-19119 10-05)
Avail NTIS HC $6.00/MF $0.95

The protective helmets developed to ameliorate the effects of impact on the head improve survival and reduce injury in aircraft accidents. However they would be aided by improvements in restraint systems and better work space design. Aircrew protective helmets should continue to be designed to deal with high energy rather than repetitive low energy blows. The multiple functions of helmets make it difficult to meet all requirements without excessive size and weight. Reduction in both weight and size would be desirable, but current standards of protection should be maintained. The impact test method used in helmet development should take accident findings into account and should involve a small number of high energy blows Author

N72-19161# Michigan Univ., Ann Arbor. Biomechanics Dept.
THE BIOMECHANICAL ASPECTS OF CRASH HELMET DESIGN
James H McElhaney, Verne L Roberts, and Richard L Stalnaker *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 8 p refs (See N72-19119 10-05)
Avail NTIS HC $6.00/MF $0.95

A head injury model capable of predicting head injury through a maximum strain criteria was developed. This model is coupled to a helmet model and the combination allows the prediction of optimum helmet performance characteristics within a given set of constraints including size and weight. Several model exercises consisting of varying coupling paramaters are presented. It was concluded that helmet performance is improved by decreasing elastic stiffness and increasing damping properties Author

N72-19162# M. L. Aviation Co., Ltd., Maidenhead (England)
THE DESIGN AND DEVELOPMENT TESTING OF AIRCREW PROTECTIVE HELMETS
J Gregory *In* AGARD Linear Acceleration of Impact Type 25 Jun 1971 7 p (See N72-19119 10-05)
Avail NTIS HC $6.00 MF $0.95

Problems of design resolution are discussed for effecting a compromise between conflicting requirements for flight helmets. There is the need to protect flight crew members from all possible consequences of a hostile environment while allowing him to carry out his primary purpose of flying or operating the aircraft efficiently without hindrance from equipment. Stages of helmet design and component assembly testing are shown in sequences to indicate development from initial shape size conception and testing of individual components to full evaluation and testing of complete prototypes. Reference is made to the design development and testing of a general purpose military aircrew protective helmet mask assembly nearing completion in the U.K. Particular attention was paid to keeping the all up weight of the assembly under 1800 g and in addition to conventional helmet facilities, incorporating an automatically lowering visor for a blast protection Author

N72-19163# Snell Memorial Foundation, Sacramento, Calif.
EVALUATION AND TESTING OF PROTECTIVE HEADGEAR
George G Snively *In* AGARD Linear Acceleration of Impact Type 26 Jun 1971 7 p (See N72-19119 10-05)
(Grant EC-00013)
Avail NTIS HC $6.00 MF $0.95

Review is made of factors which must be considered in evaluating the performance of protective headgear. Standards of performance are considered and an analysis is presented of techniques utilized in helmet testing. Special attention is given to tests for penetration resistance, retention harness strength, and protection against impact Author

N73-19143# Advisory Group for Aerospace Research and Development, Paris (France)
PERFORMANCE AND BIODYNAMIC STRESS - INFLUENCE OF INTERACTING STRESSES ON PERFORMANCE
Nov 1972 110 p refs Proc. of AGARD Aerospace Med. Panel Specialist Meeting Brussels, Jun 1972
(AGARD-CP-101) Avail NTIS HC $7.50

The interactions of operational flight stresses and their effects on human performance are considered at this conference. For individual titles see N73-19144 through N73-19156

N73-19144 Royal Aircraft Establishment, Farnborough (England) Environmental Effects Section
EARLY THOUGHTS ON COMPOUND STRAINS

Geoff Allen *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 8 p refs (For availability see N73-19143 10-05)

Jargon on the subject is briefly discussed, and it is reasoned that the term compound strains may frequently be more appropriate than combined stresses. Two compound strain problems of immediate and widespread importance, on which there is an urgent need to increase the present scanty information, are cited. The first is the effects of other mental and physical stresses on the signal to noise ratios required for communication; the second, the biodynamics of vibratory motion sickness, particularly the interaction with other loads such as vision, heat and odors. Author

N73-19146 Royal Aircraft Establishment, Farnborough (England) Human Engineering Div

A FLIGHT TEST PROGRAMME TO STUDY THE EFFECTS OF ENVIRONMENTAL STRESSES ON AIRCREW OPERATING MILITARY STRIKE AIRCRAFT

M G Trumper *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 5 p refs (For availability see N73-19143 10-05)

A flight test program is designed to obtain objective measurements of noise, vibration and temperature throughout typical profiles flown by military strike aircraft, and, as far as is possible to correlate the measurements with aircrew reaction and performance. As a secondary object the program will investigate the usefulness of a water cooled suit installation as a means of relieving aircrew thermal stress in strike aircraft. Author

N73-19146 Aerospace Medical Research Labs Wright Patterson AFB Ohio

TWO EXPERIMENTS ON THE EFFECTS OF COMBINED HEAT, NOISE AND VIBRATION STRESS

Walter F Grether *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 8 p refs (For availability see N73-19143 10-05)
(AMRL-TR-71-113)

Operational flying often exposes crew members to combinations of environmental stresses. To obtain a better understanding of such combined-stress effects a major experiment was conducted using heat, noise, and vibration, both singly and in combination. Measurements were made of tracking ability, choice reaction time, voice communication, mental arithmetic, visual acuity, body temperature, heart rate, weight loss, and subjective ratings of the stress. [illegible] of these measures did the combined triple stress [illegible] greater effects than did the most severe single [illegible] the physiological measures only heat stress produced significant effects, and the addition of noise and vibration produced no further effects. On the performance measures, particularly the tracking test, impairment was slightly less for the triple stress condition than for vibration only. Thus there were no additive interactions, and in fact some evidence of antagonistic interactions. Author

N73-19147 Aerospace Medical Research Labs Wright Patterson AFB Ohio

COMBINED EFFECTS OF NOISE AND VIBRATION ON COGNITIVE AND PSYCHOMOTOR PERFORMANCE

Henry C Sommer and C Stanley Harris *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 10 p refs (For availability see N73-19143 10-05)
(AMRL-TR-71-115)

Five studies on the combined effects of noise and vibration on psychomotor and cognitive performance are reported. Tracking and reaction time tasks were used as measures of psychomotor performance and a short term memory subtraction task was used as a measure of cognitive performance. The first study using tracking performance suggested an [illegible] effect of noise and vibration on performance; however, this was not confirmed in a second study. Two additional studies conducted with the cognitive task indicated that detrimental effects on this task occurred only when noise and vibration were combined. Further the effect seemed to be related to frequency of vibration, only 5 Hz 0.25 gz vibration combined with noise produced an adverse effect on the task. The final investigation was concerned with the effect combined noise and vibration stress had on cognitive performance as a function of time of day. The results indicate that time of day does not appear to be a particularly strong variable. Author

N73-19148 Institute of Aviation Medicine, Fliegehorst (West Germany)

SOME CRITICAL COMMENTS ON THE MEASUREMENT OF IN-FLIGHT STRAINS

W Hoffelt and K Gerbert *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 4 p refs (For availability see N73-19143 10-05)

Ways and means for aviation physicians and aviation psychologists to clarify the question of the overall stress imposed on flying personnel are discussed. Methodical difficulties are presented which result especially in the measurement of psychophysiological reactions to flying stress. Research psychological questionnaires and evaluation techniques are the only means which offer partial assessment possibilities concerning the problem of flying stress. Author

N73-19149 Royal Air Force Inst of Aviation Medicine Farnborough (England)

EMOTIONAL AND CARDIOVASCULAR STRESSES OF CENTRIFUGATION: EFFECT OF BETA RECEPTOR BLOCKADE ON HEART RATE RESPONSE

D H Glaister, M F Allnutt, M H Harrison and P Fennessy *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 13 p refs (For availability see N73-19143 10-05)

Twenty four subjects were used in a double blind trial to investigate the effect of beta adrenergic blockade on the heart rate response to acceleration. Oxprenolol 0.2 mg/kg body weight or saline placebo was injected in paired trials and subjects then performed a tracking task and submitted to three centrifuge runs. Heart rate and blood pressure were monitored continuously. Oxprenolol reduced resting heart rate, and abolished a steady increase in base line heart rate seen in placebo experiments, and attributed to activation of the adrenal medulla. Tachycardia in response to +2G sub z acceleration was prevented by beta blockade, except in a group of six subjects experiencing their first ever centrifuge ride. Heart rates at +3G sub z were lowered by oxprenolol, the persistent tachycardia being attributed to a baroreceptor reflex mediated through a reduction in vagal tone. Pulse pressure was reduced by oxprenolol especially during +3G sub z acceleration, an effect attributed to a reduction in cardiac output secondary to a fall in heart rate. Greyout tolerance was unaffected by beta blockade, but a small and unexplained decrement in tracking performance was observed. Author

N73-19150 School of Aerospace Medicine Brooks AFB Tex

ESTIMATES OF PHYSIOLOGIC RESERVE AFTER ACCELERATION EXPOSURE IN MAN

Frank R Lecocq, Richard L Lipman and Sidney D Leverett Jr *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 6 p refs (For availability see N73-19143 10-05)

A metabolic stressor was employed to provoke gluco-regulatory hormone response immediately after exposure of subjects to acceleration stress. 2-deoxy-D-glucose, a glucose analog which produces severe intracellular hypoglycemia, was infused in eight normal male volunteers during a control period, immediately after an initial experience with acceleration and after their fourth exposure to acceleration. Blood glucose, free fatty acids, insulin, growth hormone and cortisol and urinary epinephrine and norepinephrine were measured before and after each infusion of 2-deoxy-D-glucose. Although acceleration stress was modest, readily discernible changes in gluco-regulatory response to the metabolic stressor were detected after exposure to acceleration. Author

N73-19151 School of Aerospace Medicine, Brooks AFB, Tex
FINDINGS ON THE COST OF FLYING TRANSPORT MISSIONS
Bryce O Hartman and Henry B Hale *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 7 p refs (For availability see N73-19143 10-05)

Physiologic and psychologic data from airlift missions flying in an operational configuration included inflight measurements during experimental double-crew missions and basic crew missions with staging for crew rest, as well as following approximately 125 basic missions using a special workload log. Psychologic analyses have evaluated subjective fatigue, sleep, and crew workload and the relationship between these and endocrine-metabolic activity assayed via urine. The cost of flying a transport mission in the face of multiple stresses characteristic of the operational environment is considered. Author

N73-19152 Centre d'Essais en Vol, Bretigny-sur-Orge (France)
PHYSIOLOGICAL MODIFICATIONS DURING OPERATIONAL FLIGHTS OF LONG DURATION [MODIFICATIONS PHYSIOLOGIQUES AU COURS DE VOLS OPERATIONNELS DE LONGUE DUREE]
R Auffret *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 12 p refs In FRENCH (For availability see N73-19143 10-05)

Physiological changes occurring in pilots and navigators during long duration flights are examined as a function of energy fatigue. Data cover cardiac frequency, elimination of hydroxcorticosteroides in urine, elimination of mucoprotein, and glycemia levels over a 24 hour period. Transl by E H W

N73-19153 Naval Aerospace Medical Research Lab, Pensacola, Fla Human Factors Engineering Research Div
EFFECTS OF PART-WHOLE TRAINING PROCEDURES UPON THE ACQUISITION OF COMPLEX SKILLS TO BE PERFORMED UNDER STRESS
Richard S Gibson *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 4 p refs (For availability see N73-19143 10-05)

Aviation training generally follows a sequential part task approach. The question of how many tasks should be presented at one time is considered. Seventy two naval officer candidates participated in the experiment. Each subject experienced one of three training conditions prior to being exposed to the final test condition. The results provide insight into the use of part-whole training procedures for the acquisition of complex perceptual psychomotor skills. Author

N73-19154 Aerospace Medical Research Labs, Wright-Patterson AFB, Ohio
PERFORMANCE MEASUREMENT USING PILOT CONTROLLED Gz MANEUVERING WITH SIMULATED OPERATIONAL TASK
D B Rogers, F M Holden, C R Replogle, G Potor, C N Day, R E VanPatten, K A Smiles, and G C Mohr *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 5 p refs (For availability see N73-19143 10-05)
(AMRL-TR-72-3)

A technique for human performance measurement using a closed loop centrifuge has been validated. The simulation utilized the pitch and roll dynamics of a high performance aircraft. The measurement criteria were hits on target using a display generated heads up gunsight on a maneuvering target aircraft. An important consideration was relationship between man as a passive rider versus man as an active participant in the generation of the Gz stress. Two important demonstrations resulting from this study are (1) there is a significant difference in the ability of subject pilots to perform in closed versus open loop configuration and (2) it is feasible to provide a mission related human performance metric in a selective simulation in which the +Gz forces are dynamically realistic. A predictive heads up gunsight display is utilized with target trajectories representative of aerial combat maneuvers. Author

N73-19155 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
PHYSIOLOGICAL STUDIES OF FATIGUE IN ACTIVITIES REQUIRING MENTAL CONCENTRATION IN HOT CLIMATE. THE INFLUENCE OF POSITIONING AND SENSORIAL IRRITATION
J Meyer-Delius *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 8 p refs (For availability see N73-19143 10-05)

Activities of vigilance without additional influence of psychical stress or energetic upset are demonstrated in hot and temperate climate with noradrenergetic reaction. Mental effort with slightly increased energetic metabolism required 20% more time in hot climate to complete tasks than was required by persons working under temperate conditions. In this case the pulse rate was rising continuously. Under identical conditions of climate and mental work, but with noise, the pulse rate was significantly higher than without sensory irritation. Excitation of the sensorial senses leads to an additional increase in the peripheral vascular constriction. Opposed to thermoregulation it can cause disregulation and thus fatigue. Author

N73-19156 School of Aerospace Medicine, Brooks AFB, Tex Biodynamics Branch
THE USE OF PHYSIOLOGICAL PROTECTIVE MANEUVERS IN HIGH ACCELERATION ENVIRONMENTS
S J Shubrooks, Jr and S D Leverett, Jr *In* AGARD Performance and Biodyn Stress - Influence of Interacting Stresses on Performance Nov 1972 9 p refs (For availability see N73-19143 10-05)

The physiological effects of voluntary maneuvers used for protection against +G sub z acceleration were studied on the human centrifuge. During both 15-sec and 45 sec rapid onset +G sub z exposures, the increases in tolerance achieved with the Valsalva straining maneuver (forcefully exhaling against the completely closed glottis) were found to be equivalent to those achieved with the M-1 maneuver (forcefully exhaling against the partially closed glottis), either combined with use of an anti-G suit or without the suit during generalized muscular tensing. Directly measured head level arterial pressure responses correlated with these findings. The use of positive pressure breathing at levels of 25-40 mm Hg was also found to result in increases in tolerance both with and without use of the anti-G suit, at least equal to those obtained with the M-1 maneuver with less accompanying discomfort and fatigue. Author

N74-18797# Advisory Group for Aerospace Research and Development, Paris (France)
BEHAVIOURAL ASPECTS OF AIRCRAFT ACCIDENTS
K G G Corkindale, ed (Inst of Aviation Med) Dec 1973 72 p refs Papers presented at AGARD Aerospace Med Panel Specialists Meeting, Soesterberg, Netherlands, 7 Sep 1973 (AGARD-CP-132) Avail NTIS HC $6.75

A conference was conducted to discuss the influence of human factors on aircraft accidents. The subjects discussed were (1) human factors approach to aircraft accident analysis, (2) human factor in cyclic aircraft accident patterns, (3) the application of aircrew opinions on cockpit tasks and equipment to flight safety research, and (4) the psychologist's role in aircraft accident investigation. The primary purpose of the conference was to determine if research projects in human factors engineering could result in a reduction in the pilot error accident rate. For individual titles, see N74-18798 through N74-18804

N74-18798 Institute of Aviation Medicine, Fuerstenfeldbruck (West Germany)
PILOT FACTOR IN AIRCRAFT ACCIDENTS OF THE GERMAN FEDERAL ARMED FORCES
B Falckenberg *In* AGARD Behavioural Aspects of Aircraft Accidents Dec 1973 7 p refs (For availability see N74-18797 10-05)

An analysis with reference to the most frequent types of pilot error was made of 154 aircraft accidents which occurred in the years between 1967 - 1970. Of special interest were differences between pilots of jet, propeller aircraft and helic...

ters The flying experience of the pilot his age and other so called time variable factors were also taken into consideration In general errors predominantly occurred during low level flight and during the landing phase immediately before touch down In jet aircraft accidents the majority of errors committed by the pilot is due to an extreme workload in handling his aircraft In pilots of the other categories particularly on propeller driven aircraft those types of errors are more pronounced which may be attributed to the pilot s flying attitude (in extreme cases resulting in violations) The findings of other authors relating to flying experience could be confirmed As for the age distribution of pilots there were remarkable differences in comparison with the data in other publications Author

N74 18799 Naval Aerospace Medical Research Lab Pensacola Fla

HUMAN FACTORS APPROACH TO AIRCRAFT ACCIDENT ANALYSIS

Richard H Shannon and Wayne L Waag *In* AGARD Behavioural Aspects of Aircraft Accidents Dec 1973 10 p refs (For availability see N74 18797 10 05)

Naval accident reports involving the P 3 and F 4 aircraft were examined over seven and five year periods respectively The critical incident technique was used to catalogue describe and analyze operational flight crew errors in both aircraft An in depth study was performed in order to identify those problems which were common as well as specific to both aircraft The P 3 and F 4 aircraft were selected because of their completely different fleet missions and handling characteristics Human errors were categorized according to three types (1) vigilance errors (2) procedural errors and (3) perceptual motor errors Phases of flight operation were divided into four segments (1) servicing preflight postflight (2) start taxi shutdown (3) takeoff landing and (4) inflight Four remedial areas were outlined for reducing human error (1) crew coordination (2) design (3) discipline and (4) training From the F 4 accident reports 437 human errors were isolated while the P 3 reports contained 345 errors Twenty eight major error categories emerged from the analysis of these errors The accident reports were further analyzed for the errors which both aircraft had in common Twenty common error groups were found to occur in the P 3 and the F 4 representing 22 9% and 18 8 of the total errors respectively The flight segment of takeoff landing and the error type of procedures shared the most commonality across the two aircraft Author

N74 18800 Defence and Civil Inst of Environmental Medicine Downsview (Ontario)

THE HUMAN FACTOR IN CYCLIC AIRCRAFT ACCIDENT PATTERNS

Peter J Dean *In* AGARD Behavioural Aspects of Aircraft Accidents Dec 1973 8 p refs (For availability see N74 18797 10 05)

An analysis of the human factors in aircraft accidents was conducted to isolate cyclic human factors which cause the accidents The operational record of the CF 104 aircraft was used for the analysis It was determined that the accidents tend to occur more frequently in January April July and October than in the other months The subjects discussed are (1) the nature of the cyclic phenomena and how they influence man (2) previous studies of cyclic patterns in aircraft accidents and (3) specific cyclic factors related to aircraft accidents and recommendations for preventing aircraft accidents Author

N74 18801 Bunker Ramo Corp Westlake Village Calif

EVALUATION OF THE ROLE OF THE SIMULATOR IN TRAINING AIRBORNE ASW OPERATIONS

James E Robins Dorothy L Finley and Thomas G Ryan *In* AGARD Behavioural Aspects of Aircraft Accident Dec 1973 8 p Sponsored by Naval Training Equipment Center (For availability see N74 18797 10 05)

The effectiveness of the U S Navy device 2F69B a weapons trainer for the P3A and P3B aircraft was investigated The device provides tactics crews with team training in the detection tracking and destruction of modern deep diving submarines Careful selection variation and control of problem conditions should enable instructors to train the tactics teams to analyze and respond to situations likely to occur during actual ASW missions Study results indicate that learning takes place in the simulator and that there is positive transfer to the operational environment There is room for improvement and modification of the training curriculum Author

N74 18802 Royal Air Force Inst of Aviation Medicine Farnborough (England)

THE APPLICATION OF AIRCREW OPINIONS ON COCKPIT TASKS AND EQUIPMENT TO FLIGHT SAFETY RESEARCH

J M Rolfe and J W Chappelow *In* AGARD Behavioural Aspects of Aircraft Accidents Dec 1973 5 p ref (For availability see N74 18797 10 05)

A study was conducted to determine the impact of flight crew opinions on flight tasks and aircraft equipment on aircraft accidents which could be related to personnel error The areas of investigation were (1) the load imposed on the flight crew in the performance of these duties and (2) the compatibility between the aircraft equipment and the human limitations and abilities Tables of data are provided to show the results of a questionnaire submitted to flight crew personnel Author

N74 18803 Royal Air Force Inst of Aviation Medicine Farnborough (England)

THE PSYCHOLOGIST'S ROLE IN AIRCRAFT ACCIDENT INVESTIGATION

M F Allnutt *In* AGARD Behavioural Aspects of Aircraft Accidents Dec 1973 6 p (For availability see N74 18797 10 05)

The contributions to be made by psychologists in the reduction of human error aircraft accidents are discussed Specific areas of cooperation are identified as (1) analysis of human error accident data (2) research on human factor aspects of flight safety and (3) assist in determining the causes of specific aircraft accidents The advantages of using psychologists in the aircraft accident investigation are reported Author

N74 18804 Army Agency for Aviation Safety Fort Rucker Ala

INCIDENCE COST AND FACTOR ANALYSIS OF PILOT ERROR ACCIDENTS IN US ARMY AVIATION

Darwin S Ricketson Scott A Johnson Larry B Branham and Richard K Dean *In* AGARD Behavioural Aspects of Aircraft Accidents Dec 1973 19 p refs (For availability see N74 18797 10 05)

From 1959 through 1972 pilot error was a consistently large and costly cause of accidents Past analytic and prevention efforts have not approached pilot error accidents in the context of malfunctions among the basic man machine environment elements Such an approach was proposed and seeks to identify the common human error events in pilot error accidents A partial test of this approach was made with helicopter and airplane mishap information in its present form A factor analysis produced nine distinct meaningful and representative helicopter and airplane factors A component score analysis yielded pilot and mishap background information which was helpful in interpreting the factors An experimental human error events reporting form was developed which holds promise for clearer identification of mishap causing system elements and corrective measures required Author

N74 20732# Advisory Group for Aerospace Research and Development Paris (France)

THE USE OF NYSTAGMOGRAPHY IN AVIATION MEDICINE

Fred E Guedry Jr ed (Naval Aerospace Med Res Lab) Dec 1973 184 p refs Partly in FRENCH and in ENGLISH Presented at the AGARD Aerospace Med Panel Specialists Meeting Pensacola Fla 14 15 May 1973

(AGARD CP 128) Avail NTIS HC $12 25

Laboratory and clinical application techniques of nystagmography are reported with emphasis on motion sickness spatial disorientation and vertigo as experienced by flying personnel and divers For individual titles see N74 20733 through N74 20756

N74-20733 Tulane Univ New Orleans La School of Medicine
CLINICAL APPLICATION OF NYSTAGMOGRAPHY
Wallace Rubin *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 3 p (For availability see N74 20732 12-05)
There are two specific clinical advantages of electronystagmography (ENG) (1) It is possible to detect spontaneous and positional nystagmus that would not be seen without its use and (2) it is possible to differentiate peripheral from central pathology and right sided from left sided peripheral lesions when there is a spontaneous nystagmus Author

N74-20734 Minnesota Univ Minneapolis School of Medicine
PRACTICAL PROBLEMS IN CLINICAL NYSTAGMOGRAPHY. 1 GUIDELINES FOR SELECTION OF EQUIPMENT
Mary Jayne Capps *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 3 p refs (For availability see N74 20732 12 05)
The basic equipment needed for a thorough evaluation of the vestibular system includes an examination chair or table a polygraphy suitable for recording nystagmus a device for producing caloric stimuli and an optokinetic stimulator The required and optional features of each of these devices have been discussed The basic equipment will permit the elicitation and recording of the various types of eye movements, i e caloric optokinetic positional and spontaneous nystagmus The evaluation of these phenomena provides a sufficiently complete picture of the state of the vestibular system Author

N74-20735 Ohio State Univ Columbus Coll of Medicine
PRACTICAL PROBLEMS IN CLINICAL NYSTAGMOGRAPHY 2 SOURCES OF ERROR
Charles W Stockwell and William E Collins (FAA Oklahoma City) *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 10 p refs (For availability see N74 20732 12 05)
The value of clinical nystagmography can be greatly diminished if certain errors are not recognized and avoided Some errors are introduced by faulty recording techniques, including inadequate calibration inappropriate choice of frequency filters and failure to identify artifacts Other errors are due to the extreme sensitivity of the nystagmus response to extravestibular influences Caloric testing errors include inadequate stimulus control and failure to account for directional preponderance These and other errors in nystagmography are pointed out and discussed and corrective measures are suggested Author

N74-20736 Royal Air Force Inst of Aviation Medicine Farnborough (England)
USE OF NYSTAGMOGRAPHY IN THE STUDY OF AIRCREW WITH SPATIAL DISORIENTATION
A J Benson *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 13 p refs (For availability see N74 20732 12 05)
Lateral nystagmus evoked by a stopping stimulus of 60 deg/sec was recorded by electro oculography in 133 aircrew who had come under medical care because of airsickness spatial disorientation or other sensory disturbances in flight without illusory perception of aircraft orientation Measures of the slow phase velocity the time constant of decay and total amplitude of the post rotational nystagmus did not differ between the three groups Measures of directional preponderance were found to have differences in variance structure between the groups Measures of directional preponderance were found to have differences in various structure between the groups but these were not well defined and hence of limited value in the selection or assessment of individual aircrew Author

N74-20737 Centre Principal d Expertises Medicales du Personnel Navigant Paris (France)
A PROPOSED HABITUATION LABYRINTH (PRESENTATION OF SEVERAL RESULTS WITH THE P N T) [A PROPOS DE L'HABITUATION LABYRINTHIQUE (PRESENTATION DE QUELQUES RESULTATS CHEZ LA P N T)]
A Gibert P Blanc F Lafontaine P Pialoux and P Fontelle *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 7 p In FRENCH (For availability see N74 20732 12 05)
Several methods with special emphasis on damp sinusoidal stimulation used to study labyrinth are introduced Data are also given on the possible application of these methods in aeronautical and aerospace medicine Habituation phenomena using the personnel navigation technique are given as well as information obtained by observing the phenomena in the course of professional apprenticeship The possibility of observing the equilibration function during professional life particularly during the course and abatement of the central peripheral vertiginous syndrome was discussed Transl by E H W

N74-20738 Hopital d Instruction des Armees Versailles (France)
INTEREST OF NYSTAGMOGRAPHY IN FLYING NAVIGATION PERSONNEL [INTERET DE LA NYSTAGMOGRAPHIE DANS LE PERSONNEL NAVIGATION DE L'AVIATION]
L R Burdes *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 6 p In FRENCH (For availability see N74 20732 12 05)
The use of electronystagmography to diagnose psycholabyrinth hyporeflective and barotrumatism vestibula and peripherial radicular and central syndromes in navigation personnel is discussed Test results are included along with data on the possible use of the method as an aid in selecting navigation personnel Transl by E H W

N74-20739 Italian Air Force Aerospace Medical Center Rome
A CONTRIBUTION TO THE ELECTRONYSTAGMOGRAPHIC METHOD CONCERNING THE INTERPRETATION OF NYSTAGMUS CHARACTERISTICS
C Koch *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 5 p refs (For availability see N74 20732 12 05)
The evaluation of nystagmic characteristics is stressed both from a quantitative and qualitative standpoint Descriptions of some of them (amplitude frequency duration) are given the importance of which is well known as far as vestibular semiology and diagnostics are concerned A new formula is proposed concerning the interpretation of the electronystagmographic recording This formula makes it easier to define the nystagmus in degrees thus constituting a basis for its classification Author

N74-20740 Illinois Univ Chicago Abraham Lincoln School of Medicine
DIFFERENTIAL DIAGNOSIS OF THE CALORIC NYSTAGMUS
Nicholas Torok *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 11 p refs (For availability see N74 20732 12 05)
Diagnostic considerations based upon the nystagmogram are limited Quantitative assessment of horizontal canal sensitivity is available through the use of culmination frequency or culmination slow phase velocity Three distinctive qualitative features of the caloric nystagmus were evaluated and were found to be suggestive or outrightly pathognomonic for retrolabyrinthine or central nervous system abnormalities These are (1) vestibular decruitment a disproportionate caloric responsiveness when a weak stimulus elicits a more intense nystagmic reaction than a strong stimulus is capable of creating (2) hyperactive vestibular responsiveness and (3) ocular fixation reversal phenomenon Elimination of fixation decreases the nystagmus intensity instead of facilitating the evoked nystagmus Author

N74-20741 McGill Univ Montreal (Quebec) Dept of Physiology
NYSTAGMOGRAPHY A USEFUL TOOL IN BASIC AND APPLIED INVESTIGATIONS
G Melvill Jones *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 13 p refs (For availability see N74 20732 12 05)
Relatively gross eye movements are considered in particular (1) quick saccadic gaze shifts from one fixation point to another (2) the relatively slow smooth pursuit movements associated

with following a fixation point which is moving relative to the head. In many circumstances these two types of movement are integrated to produce a combined pattern of eye movement suitable for intermittent fixation on a visual field which is moving relatively to the head. Methods of recording nystagmus and its data reduction are discussed together with their applicability and hazards, in relation to intended objectives. The experimental use of nystagmography is treated in terms of quick and slow phase eye movements and of head movements. Author

N74-20742 Toronto Univ. (Ontario). Dept. of Otolaryngology.
OPTOKINETIC NYSTAGMUS: ITS VALUE IN THE DIAGNOSIS OF CERTAIN VESTIBULAR LESIONS
Y. Morissette, S. M. Abel, and H. O. Barber *In* AGARD The Use of Nystagmography in Aviation Med. Dec. 1973 6 p refs (For availability see N74-20732 12-05)

Optokinetic nystagmus (OKN) was studied to explore its value in the localization of vestibular lesions. The stimulus consisted of a field of equidistant parallel black bars - either horizontal or vertical - moving across a white ground. The data showed that for subjects with normal vestibular function and unilateral labyrinthectomy, the slow phase velocity of OKN varied nonmonotonically with increases in the speed of the bars between 20 and 400 degrees of visual angle per second. This function reached a single maximum at approximately 60 to 80 degrees of bar velocity for horizontal OKN and at 40 degrees for vertical OKN. In subjects with neurological confirmed lesions of brain stem due to multiple sclerosis, tumor or ischemic disease, the slow phase velocity of OKN did not change but remained constant at about 20 degrees/sec. across the range of bar velocities studied. Author

N74-20743 Mount Sinai Medical and Graduate Schools, New York. Dept. of Neurology.
VISUAL-VESTIBULAR INTERACTION: THE ROLE OF THE LABYRINTH IN THE PRODUCTION OF OPTOKINETIC NYSTAGMUS AND OPTOKINETIC AFTER NYSTAGMUS
B. Cohen, S. Takemori, and T. Uemura *In* AGARD The Use of Nystagmography in Aviation Med. Dec. 1973 4 p ref. (For availability see N74-20732 12-05)

OKN and OKAN were affected by unilateral and bilateral labyrinthectomy. The maximum velocity of slow phases of OKN induced by drum rotations above 60-75 deg/sec in either direction was lower after unilateral and bilateral labyrinthectomy. The frequency of OKN was also decreased, and the total deviation of the eyes was reduced for OKN induced by these drum speeds. Changes in OKN eventually recovered. OKAN was reduced in duration after unilateral labyrinthectomy, being initially shorter to the ipsilateral than to the contralateral side. OKAN could no longer be evoked after bilateral labyrinthectomy. This loss was permanent. These data demonstrate the importance of the vestibular system in maintenance of OKN and OKAN. Author

N74-20744 Freiburg Univ. (West Germany). Dept. of Neurology and Neurophysiology.
SELF-MOTION SENSATION, PSEUDO-CORIOLIS EFFECTS AND MOTION SICKNESS INDUCED BY OPTOKINETIC STIMULI
Johannes Dichgans and Thomas Brandt *In* AGARD The Use of Nystagmorgraphy in Aviation Med. Dec. 1973 3 p refs (For availability see N74-20732 12-05)

Psychophysiological experiments reported establish that the human sensation of self motion is evoked by stimulation of the labyrinthine receptors as well as by excitation of the visual sense. Circularvection, pseudo coriolis effect, and visually induced tilt of the apparent vertical produce oculogravic motion illusions and motion sickness phenomena due to vestibular visual interaction. G.G.

N74-20745 Miami Univ., Oxford, Ohio. Dept. of Psychology.
EFFECTS OF SOUND ON THE VESTIBULAR SYSTEM
D. E. Parker, M. F. Reschke, and R. L. Tubbs *In* AGARD The Use of Nystagmography in Aviation Med. Dec. 1973 12 p refs (For availability see N74-20732 12-05)
(Contracts F33615-69-C-1246; F33615-73-C-4002)

The effects of sound on the vestibular systems of guinea pigs and monkeys were studied. Sound stimuli included: (1) Pressure transients, (2) infrasounds, and (3) intense audiofrequency sound. Biomechanical and physiological responses to these three types of stimuli were observed. Biomechanical responses examined included stapes displacement and perilymph pressure changes. Vestibular nerve activity, eye movements, and head movements are the physiological responses that were recorded. Monkey responses differed from guinea pig responses under several conditions; response differences suggest different mechanisms of acoustical vestibular stimulation in these two species. Author

N74-20746 Florida Univ., Gainesville. Div. of Otolaryngology.
NORMAL LIMITS FOR THE SEQUENTIAL BITHERMAL BINAURAL CALORIC TEST
Franklin O. Black, David D. Custer (Tech.-Vocational Inst.), William G. Hemenway (Colo. Univ.), and John I. Thornby *In* AGARD The Use of Nystagmography in Aviation Med. Dec. 1973 9 p refs (For availability see N74-20732 12-05)

Analysis of bithermal binaural caloric test results gave a statistically significant response difference between ears for right handed normal subjects. There were no significant response differences due to temperature of stimulation and ear stimulated. Three tests for the determination of caloric nystagmus response abnormalities were developed, based upon analysis of intrasubject normal responses. A retrospective examination of caloric responses from patients with Meniere's disease provided preliminary support for clinical feasibility and increased sensitivity of the statistical methods advocated for clinical usage. Author

N74-20747 Mainz Univ. (West Germany). Dept. of Physiology.
HUMAN EYE MOVEMENTS DURING VARIOUS FORMS OF LINEAR ACCELERATION AND WEIGHTLESSNESS
R. J. VonBaumgarten, R. Thumler (Mich. Univ.), C. I. Shillinger, Jr. (NASA. Ames Res. Center), and G. Baldrighi (Mich. Univ.) *In* AGARD The Use of Nystagmography in Aviation Med. Dec. 1973 3 p refs (For availability see N74-20732 12-05)

Eye movements of human subjects were recorded electronystagmographically in complete darkness during rectilinear horizontal accelerations as achieved in cars on the ground and also during aircraft parabolic flight. The results were compared to the movements of blinded goldfish subjected to similar changes of gravitoinertial forces. The results indicate that there is a human correlation with the gravity reference response of fish. During horizontal forward accelerations on the ground the human eyes turn downward and during horizontal backward acceleration the eyes turn upward. The human eye response to g loads below 1 g and to weightlessness is the reverse of the tilt of the fish. While fish dive down during low g or loop forward during weightlessness, the eyes of subjects sitting upright in an aircraft which flies at 0 g move upward. Author

N74-20748 Ludwig-Maximilians Universitat, Munich (West Germany).
THERMOELECTRIC STIMULATION OF THE LABYRINTH
Hans Scherer *In* AGARD The Use of Nystagmography in Aviation Med. Dec. 1973 5 p (For availability see N74-20732 12-05)

A new method of caloric labyrinth stimulation is described. The use of water as a stimulator is replaced by a copper plug positioned in the external ear canal. The plug's temperature is regulated by Peltier thermoelectric plates which are connected with a power supply and are able to produce on one of their sides either heat or cold. Every temperature necessary to stimulate the labyrinth can be applied. Electronic steering and the automatization of the whole test are easily applicable. The new method is especially useful in patients with lesions of the ear drum. Several typical examples of thermoelectric stimulation of the labyrinth and the nystagmic response are shown. Author

N74-20749 Ulm Univ. (West Germany). Dept. of Neurology.
COMPUTER-ELECTRONYSTAGMOGRAPHY IN EVALUATING THE INFLUENCE OF PSYCHO PHARMACOLOGICAL DRUGS ON VIGILANCE
Juergen C. Aschoff and Wolfgang Becker *In* AGARD The Use of Nystagmography in Aviation Med. Dec. 1973 8 p refs (For availability see N74-20732 12-05)

Maximum velocity and duration of saccadic eye movements depend entirely on the magnitude of angular deflection of the eye ball, and on the state of alertness or fatigue. Tranquilizing drugs such as Diazepam are known to reduce significantly the maximum velocity, but accuracy and reaction time of these eye movements deteriorate, too. For evaluating these drugs, an on-line computer program has been developed whereby 500 saccadic eye movements are computed for their maximum velocity, duration, accuracy and reaction time. All desired parameters are plotted in amplitude subgroups with mean values + or - standard deviation. Various drugs have been tested using this method including a powerful new antidepressant drug Sulpiride. This antidepressant psychopharmakon showed no influence on velocity and reaction time and may even enhance accuracy of saccadic eye movements. Author

N74-20760 School of Aerospace Medicine, Brooks AFB, Tex. Clinical Sciences Div.

AEROMEDICAL RESEARCH AND CLINICAL APPLICATIONS OF AVERAGING TECHNIQUES IN NYSTAGMOGRAPHY

James W Wolfe *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 6 p refs (For availability see N74-20732 12-05)

A system employing analog-to-digital techniques has been developed for simultaneously measuring the average slow and fast phase velocity of the summated response and left and right eye movements separately and for precisely resolving both of these variables. This method is described along with illustrative cases. Preliminary results indicate that this approach may be useful in differentiating peripheral and central vestibulo-oculomotor pathology. Author

N74-20761* Massachusetts Inst. of Tech., Cambridge. Man-Vehicle Lab.

AUTOMATED NYSTAGMUS ANALYSIS

Charles M Oman, John H J Allum, John R Tole and Laurence R Young *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 9 p refs (For availability see N74-20732 12-05)

(Grants NGR-22-009-025, NGR-22-009-156, NGR-22-009-701)

Several methods have recently been used for on-line analysis of nystagmus. A digital computer program has been developed to accept sampled records of eye position, detect fast phase components, and output cumulative slow phase position, continuous slow phase velocity, instantaneous fast phase frequency, and other parameters. The slow phase velocity is obtained by differentiation of the calculated cumulative position rather than the original eye movement record. Also, a prototype analog device has been devised which calculates the velocity of the slow phase component during caloric testing. Examples of clinical and research eye movement records analyzed with these devices are shown. Author

N74-20762 Royal Air Force Inst. of Aviation Medicine, Farnborough (England)

A MODEL FOR THE PREDICTION OF THE NYSTAGMIC RESPONSE TO ANGULAR AND LINEAR ACCELERATION STIMULI

G R Barnes and A J Benson *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 13 p refs (For availability see N74-20732 12-05)

A model has been developed for the mechanism of saccadic generation in the vestibulo-ocular reflex arc, in an attempt to explain variations in the pattern of nystagmic response to vestibular stimulation. The model has been developed using an analogue computer and an attempt has been made to relate the system to the known physiological evidence. The response of the model has been compared with results from experiments on human subjects, and satisfactory agreement has been obtained in conditions appropriate to stimulation of the canals by both periodic and transient angular accelerations and to stimulation of the utricular maculae by linear acceleration. The model effectively simulates the changes in frequency and duration of slow phase and saccadic eye movements observed experimentally. Author

N74-20763 Royal Australian Navy School of Underwater Medicine, Balmoral

VERTIGO IN DIVING

Carl Edmonds *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 10 p refs (For availability see N74-20732 12-05)

Because vertigo is associated with nystagmus and this can be demonstrated in an objective manner, it has been attempted to differentiate the specific causes of vertigo from those of disorientation in general. It is fully appreciated that there is a strong correlation between these two symptoms. An aetiological classification of vertigo in diving is reported that considers aspects of unequal vestibular stimulation as well as unequal vestibular responses. Author

N74-20764 Duke Univ., Durham, N.C. Div. of Otolaryngology.

COCHLEAR AND VESTIBULAR INJURIES DURING DIVING

Joseph C Farmer, Jr. *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 8 p refs (For availability see N74-20732 12-05)

Cochlear and vestibular damage can occur during all phases of diving. Inner ear damage during compression seems to be related to difficulties with middle ear pressure equalization while such damage occurring at stable deep depths seems to be related to experimental changes in inspired inert gas composition. Cochlear and vestibular damage during decompression seems to be a form of decompression sickness and can be the only manifestation of this problem. Twenty cases of such damage are presented in which there is a significant correlation between prompt recompression treatment and lack of residual deficites. Excessive noise is not uncommon during various diving conditions and can lead to temporary and presumably permanent auditory thresholds shifts. Author

N74-20765 Lund Univ. (Sweden). ENT-Dept.

EFFECTS OF INCREASED MIDDLE EAR PRESSURE ON THE VESTIBULAR SYSTEM

Oerjan Tjernstroem *In* AGARD The Use of Nystagmography in Aviation Med Dec 1973 9 p refs (For availability see N74-20732 12-05)

A technique is described for measuring changes in pressure in the middle ear. Fitted to the external ear canal is a rubber cuff which contains a small tube. A flowmeter, parallel with the tube, detects airflow between the external ear canal and the ambient air. The airflow is compared electronically with a reference airflow in another tube which emanates from an adjustable reference volume. By recording in this manner in a pressure chamber, pressure changes in the middle ear could be related to report vertigo and also to recorded nystagmus. Results indicate that alternobaric vertigo (A V) may occur with only moderate pressure changes and that some subjects who would otherwise be regarded as normal are especially susceptible to A V, apparently as a result of a high forcing pressure on one side. Author

06 CHEMISTRY

Includes chemical analysis and identification (e.g. spectroscopy). For applications see 17 Materials, Metallic, 18 Materials, Nonmetallic; and 27 Propellants

N73-31830# Advisory Group for Aerospace Research and Development, Paris (France).
GAS SAMPLING AND ANALYSIS IN COMBUSTION PHENOMENA
G. Lengelle (ONERA, Paris) and C. Verdier (ONERA, Paris) Jul. 1973 185 p refs
(AGARD-AG-168; AGARDOGRAPH-168) Avail: NTIS HC $11.25

The application of gas analysis techniques to determine combustion efficiency in turbine engines and rocket engine combustion chambers is discussed. The fundamental data for combustion kinetics in a perfectly stirred reactor and in premixed laminar flames are reported. Various methods of gas analysis using gas phase chromatography, mass spectrometry, absorption of electromagnetic, absorption of electromagnetic radiations, and physicochemical methods of flow-through analysis are explained. Author

N74-22799# Advisory Group for Aerospace Research and Development, Paris (France)
GAS SAMPLING AND ANALYSIS IN COMBUSTION PHENOMENA [PRELEVEMENT ET ANALYSE DE GAZ DANS LES PHENOMENES DE COMBUSTION]
G. Lengelle (ONERA, Paris) and C. Verdier (ONERA, Paris) Jul 1973 187 p refs In FRENCH
(AGARDograph-168(FR), AGARD-AG-168(FR)) Avail NTIS HC $12.50

The application of gas analysis techniques to determine combustion efficiency in turbine engines and rocket engine combustion chambers is discussed. The fundamental data for combustion kinetics in a perfectly stirred reactor and in premixed laminar flames are reported. Various methods of gas analysis using gas phase chromatography, mass spectrometry, absorption of electromagnetic radiations, and physiochemical methods of flow-through analysis are explained Author

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07 COMMUNICATIONS

Includes communications equipment and techniques, noise, radio and communications blackout, modulation telemetry, tracking radar and optical observation, and wave propagation. For basic research see 23 Physics, General, and 21 Navigation

N71-19526# Advisory Group for Aerospace Research and Development, Paris (France)

INFORMATION ANALYSIS CENTRES

Feb 1971 59 p refs Conf held at Amsterdam 10 Nov 1970
(AGARD-CP-78-71) Avail NTIS

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4 THE HARWELL HEAT TRANSFER AND FLUID FLOW INFORMATION ANALYSIS CENTRE L B Cousins (UKAEA, Harwell, England) 8 p (See N71-19530 09-33)

5 PROPOSAL FOR AN INTERNATIONAL AIR POLLUTION INFORMATION ANALYSIS CENTER J W Murdock (Battelle Memorial Inst, Columbus, Ohio) 5 p (See N71 19531 09-13)

6 MARITIME POLLUTION R P Langston (Admiralty Oil Lab, Cobham England) 7 p refs (See N71-19532 09-13)

N71-19527# Battelle Memorial Inst, Columbus, Ohio

CONCEPT, MISSION, AND OPERATION OF SCIENTIFIC AND TECHNICAL INFORMATION ANALYSIS CENTERS

J W Murdock *In* AGARD Inform Analysis Centers Feb 1971 14 p (See N71-19526 09-07)
Avail NTIS

A discussion is given of the fundamental concepts of an information analysis center (IAC) and how it relates to other information services The mission of an IAC is considered in terms of how unpublished information is obtained and used, and how feedback helps the IAC achieve its goals Operational aspects of a center are reviewed and experiences by research scientists and engineers in utilizing an IAC are related Two non-government supported IAC s are described along with one government center The advantages of working in an IAC environment, key problems in day-to-day operation and the ever present problem of money are included in the discussion D L G

N71-19528# Battelle Memorial Inst, Columbus, Ohio

FUNDING INFORMATION ANALYSIS CENTERS

G S Simpson Jr *In* AGARD Inform Analysis Centres Feb 1971 4 p (See N71 19526 09-07)
Avail NTIS

An overview is presented of the funding problems involved in the implementation and maintenance of an information analysis center It is pointed out that (1) the centers are expensive to operate (2) adequate funding is difficult to obtain and keep, and (3) the centers cannot be economically justified for every aspect of science and engineering Another basic problem involves the difficulty in acquiring detailed data cost from facilities that are presently in operation Emphasis of the discussion is placed on factors that determine whether an information analysis center is needed what size it should be, and whether it should be funded by government sources or private industry D L G

N71-19529# Societe Nationale Industrielle Aerospatiale, Paris (France) Div Systemes Balistiques et Spatiaux

A SPECIALIZED DOCUMENTATION CENTER: ITS ORGANIZATION, ITS METHODS, ITS EFFECTIVENESS [UN CENTRE DE DOCUMENTATION SPECIALISE: SON ORGANISATION, SES METHODES, SON EFFICACITE]

Y J Roeper *In* AGARD Inform Analysis Centres Feb 1971 11 p In FRENCH, ENGLISH summary (See N71-19526 09-07)
Avail US Patent Office

The establishment and operation procedures are described for a documentation center dealing with aerospace data Discussions are given concerning (1) the need for such a center, (2) the documentation chain employed (3) the automatization involved, and (4) cost effectiveness In addition, some figures are provided to illustrate the cost of automatic documentation D L G

N71-19530# United Kingdom Atomic Energy Authority, Harwell (England)

THE HARWELL HEAT TRANSFER AND FLUID FLOW INFORMATION ANALYSIS CENTRE

L B Cousins *In* AGARD Inform Analysis Centres Feb 1971 (See N71 19526 09 07) 8 p
Avail NTIS

The establishment of a service to meet the information requirements of a specific group of scientists and technologists is described The setting up of a reference library for heat transfer and fluid flow literature is outlined and the methods employed for rapid retrieval of that literature using a large digital computer are given Author

N71-19531# Battelle Memorial Inst Columbus, Ohio

PROPOSAL FOR AN INTERNATIONAL AIR POLLUTION INFORMATION ANALYSIS CENTER

John W Murdock *In* AGARD Inform Analysis Centres Feb 1971 5 p (See N71 19526 09-07)
Avail NTIS

The establishment within NATO of an international information analysis center on air pollution is proposed The application of information analysis concepts to this critical field which increasingly involves multidisciplinary research and development efforts in all the industrialized societies of the world, would create a comprehensive base of knowledge that would be utilized by (1) research scientists of many nations to assure maximum effective contributions to solving air pollution problems and (2) by administrators and policy makers to make the major decisions that determine what research is to be done and how it is to be funded Methods of establishing the information analysis center its organization and the functions of its international staff are described Author

N71-19532# Admiralty Oil Lab Cobham (England)

MARITIME POLLUTION

R P Langston *In* AGARD Inform Analysis Centres Feb 1971 7 p refs (See N71 19526 09 07)
Avail NTIS

A discussion is presented on the feasibility of an international maritime pollution information analysis center Emphasis is placed on the growing recognition of the need for a better understanding of what takes place when oil products are spilled at sea The proposed center would process on an international basis, all data dealing with the nature of oil spills, the consequences and the technologies employed in the cleaning up process In addition incidences of oil spillage would be reported to the center and this information would be routinely processed and disseminated to all member countries Other benefits that could be derived from the proposed center are briefly discussed and include (1) the acquisition of data on weather conditions and water movements (2) the

availability of industrial and ecological information. (3) the identification of pollutants, and (4) the formulation of legal aspects and medical/toxic aspects. D L G

N71-21409# Advisory Group for Aerospace Research and Development, Paris (France)
TROPOSPHERIC RADIO WAVE PROPAGATION, PART 1 Conference Proceedings
H. J Albrecht, ed Feb. 1971 309 p refs Mostly in ENGLISH, partly in FRENCH AGARD Avionics Panel 16th Tech Symp held in Dusseldorf, 31 Aug 4 Sept 1970
(AGARD-CP-70-71-Pt-1) Avail NTIS

Electromagnetic wave propagation through the troposphere is analyzed for the effects of tropospheric characteristics on wave refelection and refraction, scatter propagation, and propagation vediction methods For individual titles, see N71-21410 through N71-21433

N71-21410# Advisory Group for Aerospace Research and Development, Paris (France) Communications Electronics Div of the Military Committee
MILITARY APPLICATIONS OF RESEARCH AND DEVELOPMENT IN TROPOSPHERIC WAVE PROPAGATION
Enrico Scotti (Italian Army) *In its* Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 4 p (See N71-21409 10-07)
Avail NTIS

An overview of military applications of tropospheric propagation phenomena in scatter communications and radar is presented with emphasis on the problems encountered by military communications, sensor systems command and control, frequency planning and the NATO integrated communications system is discussed A better correlation of the known aspects of tropospheric propagation so as to best support military systems planning is advocated Author

N71-21411# Advisory Group for Aerospace Research and Development, Paris (France)
THE STRUCTURE AND DYNAMICS OF THE TROPOSPHERE
P. Raethjen *In its* Tropospheric Radio Wave Propagation, Pt 1 Feb. 1971 12 p (See N71-21409 10-07)
Avail. NTIS

A three-fluids general atmospheric circulation model is described that uses a large rotating water bowl to realize Prandl's theoretical atmospheric flow model Experimental results obtained with the water basin containing three liquids of differing densities indicate that a weak meridian flow polewards is the cause of strong western winds Atmospheric cyclones at higher latitudes originate where an upper branch of meridian circulation, far advanced in a direction towards the pole, commences its descent G G

N71-21412# Environmental Science Services Administration, Boulder, Colo
WORLDWIDE CHARACTERISTICS OF REFRACTIVE INDEX AND CLIMATOLOGICAL EFFECTS
B. R. Bean, E A Hart, and G D Thayer *In* AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 14 p refs (See N71-21409 10-07)
Avail. NTIS

The development and present status of radio climatology are reviewed, from Newton's use of the exponential atmosphere to recent work on the climatology of radio refractive index turbulence. (1) development of models of the general vertical structure of the refractive index with a three-part exponential profile, (2) the general refractive index gradient, elevated layers with strong refractive index gradients, and winds in the common volume region which are significant to the performance of transhorizon radio propagation systems, (3) studies of the climatology of the initial gradient of the radio refractive index which have revealed that the tropical areas of the world experience the most severe conditions, and (4) the likelihood of turbulence of the radio refractive index as determined from the gradient of the potential refractive index and calculated from conventional meteorological soundings of the atmosphere. Author

N71-21413# General Electric Co., Syracuse, N Y
TROPOSPHERIC EFFECTS ON SPACE COMMUNICATIONS
George H Millman *In* AGARD Tropospheric Radio wave Propagation, Pt 1 Feb 1971 30 p refs (See N71-21409 10-07)
Avail NTIS

The influence of the natural environment is considered in the design of an earth satellite communication system The nonisotropic characteristics of the troposphere are evaluated in terms of their effects on the propagation of electromagnetic waves through the medium The tropospheric propagational phenomena which are discussed are refraction, time delay, scintillation effects, doppler frequency shift, ducting, attenuation, and noise Author

N71-21414# Stanford Research Inst, Calif Aerophysics Lab
SATELLITE VIEWED CLOUD COVER AS A DESCRIPTOR OF RADIO-RADAR PROPAGATION CONDITIONS
R H Blackmer Jr and S M Serebreny *In* AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 12 p (See N71-21409 10-07)
Avail NTIS

Comparison is made between the appearance of a satellite viewed cloud cover and radio-radar propagation conditions to determine whether cloud cover can describe atmospheric conditions influencing radio-radar propagation Radar performance records from the eastern Pacific Ocean and tropospheric scatter signals from the southwestern Pacific ocean were compared with satellite photographs of cloud cover over the respective areas It is shown that the nature of the cloud cover helps to indicate whether propagation will be normal or abnormal but more research is needed to obtain quantitative propagation data over small scale areas Author

N71-21415# Air Force Cambridge Research Labs, Bedford, Mass
RAIN ATTENUATION AT MILLIMETER WAVELENGTHS
E E Altshuler, V J Falcone, and K N Wulfsberg *In* AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 10 p refs (See N71-21409 10-07)
Avail NTIS

A program to determine the feasibility of using millimeter waves for space communication has been conducted and it has been shown that at 15 and 35 GHz atmospheric attentuation is relatively low except for conditions of heavy clouds and vecipitation Rain attenuation was measured in Hilo Hawaii and the following results were obtained (1) total atmospheric attenuation is moderately low at 15 and 35 GHz for rainfall rates less than 1 mm/hr and zenith angles less than 45 deg For higher rainfall rates and angles closer to the horizon the attenuation becomes prohibitive particularly at 35 GHz, (2) total atmospheric attenuation can be accurately calculated from a measurement of apparent sky temperature, and (3) atmospheric attenuations at 15 and 35 GHz are highly correlated Author

N71-21416# McGill Univ, Montreal (Quebec)
APPLICATION OF WEATHER RADAR DATA TO PROPAGATION QUESTIONS
R R Rogers *In* AGARD Tropospheric Radio Wave Propagation Pt 1 Feb 1971 11 p refs Supported by Can Dept of Commun (See N71-21409 10-07)
Avail NTIS

The weather radar facility instrument provides a real time

display of the 10GHz attenuation due to rainalong the radar line of sight Three months' data from two summers have been analyzed to given attenuation statistics for application to communications over terrestrial and satellite microwave links Preliminary results are presented for the azimuth extent, duration, and frequency of occurrence of attenuations ranging from 5 to 30 GHz at elevation angles between 3 deg and 20 deg Author

N71-21417# Communications Research Centre, Ottawa (Ontario)
SIMULTANEOUS MEASUREMENTS OF PRECIPITATION ATTENUATION AND RADAR REFLECTIVITY AT CENTIMETRE WAVELENGTHS
K. S. McCormick *In* AGARD Tropospheric Radio Wave Propagation. Pt 1 Feb 1971 12 p refs (See N71-21409 10-07)
Avail. NTIS

Measurements have been made of precipitation attenuation along slant paths through the troposphere Beacons at 4. 8 and 15 GHz were carried by an aircraft which flew in circular paths around a receiving antenna. with elevation angles to the aircraft for different flights between 3 and 20 degrees Simultaneous measurements of backscatter from precipitation along the propagation path were made using a 2 9 GH weather radar The radar data have been used to calculate values of the path attenuation, using empirical relations to relate attenuation to reflectivity factor Data were obtained for situations including moderate widespread rain, an intense shower, rain cells which apparently contained hail in their cores, and situations in which a distinct melting layer was present. On the basis of the measured data, it is concluded that the radar can be used to calculate values of path attenuation that give satisfactory agreement with the observed values, provided that hail or a melting layer is not intercepted by the radar beam Author

N71-21418# Texas Univ., Austin Electrical Engineering Research Lab
COMPARISON OF 15 GHz PROPAGATION DATA FROM THE ATS 5 SATELLITE WITH GROUND BASED RADIO AND METEOROLOGICAL DATA
A W Straiton and S M Fannin *In* AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 10 p refs (See N71-21409 10-07)
Avail NTIS

15 GHz signals transmitted from the ATS-5 satellite and related ground based observations are discussed The purpose of the experiments is to determine the reliability and predictability of communication from space at frequencies higher than presently used The ATS-5 satellite was put in synchronous orbit at 108 deg West longitude Failure in one of the positioning jets prevented stabilization with a resulting rotation 76 cycles per minute However, it was possible to determine significant information on the transmission characteristics of the atmosphere Various ancillary data were taken including wind speed and direction, temperature, rain rate and distribution, sky temperature and surface radio wave attenuation Author

N71-21419# Communications Research Centre Ottawa (Ontario)
MICROWAVE ATTENUATION MEASUREMENTS USING THE ATS 5 SATELLITE
J I Strickland and J W B Day *In* AGARD Tropospheric Radio Wave Propagation. Pt 1 Feb 1971 7 p refs (See N71-21409 10-07)
Avail NTIS

The attenuation by precipitation a 15 3 GHz signal is being measured for slant paths of 30 degrees elevation angle using the beacon transmissions of the ATS-5 satellite The sky temperature at 15 3 GHz along the propagation path is measured simultaneously with a total power radiometer Predicted attenuations are calculated from measured values of the sky temperature Backscatter of radiation of 2 9 GHA GHz is measured with a collocated S-band radar Values of mean radar reflectivity are calculated and path attenuations at 15.3 GHz derived Generally good agreement between radiometer predicted, radar predicted, and directly measured attenuations is obtained Author

N71-21420# Max-Planck-Institut fur Aeronomie, Lindau uber Northeim (West Germany) Abteilung Weltraumphysik
INFLUENCE OF THE TROPOSPHERE ON LOW INCIDENT SATELLITE SIGNALS IN THE RANGE OF WAVELENGTH 15 TO 2 m
G K Hartmann *In* AGARD Tropospheric Radio Wave Propagation. Pt 1 Feb 1971 11 p (See N71-21409 10-07)
Avail: NTIS

The amplitude of radio signals from the beacon satellite Explorer 22 has been recorded since November 1964 for the purpose of obtaining the ionospheric electron content from the Faraday effect On a considerable number of occasions when the satellite was at low elevation angles, sudden increases in signal amplitude were observed Detailed investigations show that these enhancements are the results of diffractions of the radio waves by structuers within the troposphere These effects were observed on 20 MHz, 40 MHz, 41 MHz and 136 MHz Detailed investigations of Explorer 22 records from 1965-1968 revealed that about 6% of all recordings showed these tropospheric effects Very recent observations with signals from the geostationary satellite ATS 3 on 137 350 MHz and 412 05 MHz clearly demonstrated that similar effects were detectable Author

N71-21421# Forschungsinstitut fuer Hochfrequenzphysik Bonn (West Germany)
TROPOSPHERIC PATH PARAMETERS WITH MULTIPLE ACCESS SYSTEMS IN SPACE COMMUNICATIONS
H J Albrecht and R Makaruschka *In* AGARD Tropospheric Radio Wave Propagation. Pt 1 Feb 1971 19 p Sponsored by Min of Defence. Federal Rep of Ger (See N71-21409 10-07)
Avail NTIS

Design aspects for optimized multiple access systems with reference to variable tropospheric conditions are discussed Particular mention is made of frequency division multiple access (FDMA), time division multiple access (TDMA), and code division multiple access (DCMA) The tropospheric parameters which are likely to influence the choice of the multiple access systems as for instance turbulence with variable turbulence characteristics layer-like occurrences in the lower and upper troposphere, and effects of ground inversion layers are described In each case, the dependence of the tropospheric path links upon the effective elevation angle of operation is considered a major criterion Author

N71-21422# Air Force Systems Command Wright-Patterson AFB Ohio Avionics Lab
THE EFFECT OF THE PROPAGATION MEDIUM ON HIGH DATA RATE TRANSMISSIONS AT LOW ELEVATION ANGLES
W T Hunt *In* AGARD Tropospheric Radio Wave Propagation. Pt 1 Feb 1971 9 p refs (See N71-21409 10 07)
Avail NTIS

A radio wave passing through a turbulent propagation medium such as the troposphere, suffers distortions which are equivalent to the generation of new signals or propagation medium noise The desired signal will be modulated, causing unwanted noise and erroneous interpretation of the recieved signals This problem increases greatly when one or both terminals are moving rapidly through turbulent media The problem is greatly accentuated at elevation angles of less than 10 degrees because of the longer path the signal has to travel through the troposphere and because of multipath effects Aircraft-to-ground tests at S-band frequencies utilizing a 250,000 bit/sec rate and satellite-to-ground tests at X-band frequencies have been conducted at bandwidths of 8 MHz These tests are described and some of the results are summarized Author

N71-21423# Radio and Space Research Station, Slough (England)

EFFECTS OF TROPOSPHERIC LAYER STRUCTURE ON PROPAGATION AND SIGNAL DISTORTION

J. A. Lane *In* AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 14 p refs (See N71-21409 10-07)

Avail NTIS

The nature of elevated layers of large vertical gradient of refractivity in the troposphere is discussed. In addition to earlier observations with refractometers on aircraft, much important information has been obtained with balloon-borne instruments, optical radar (lidar), acoustic radar, and centimeter radar of high resolution. Some degree of stratification in the first few kilometers above ground is now known to be relatively common, but the precise effect of such stratification on signal strength, fading characteristics, Doppler spectrum, available bandwidth, space diversity and gain degradation has been investigated in relatively few investigations. The significance of dynamic stability is discussed and recent experiments of special importance are reviewed in relation to those results which are especially relevant to the physical nature of layer structure and theories of turbulence. Author

N71-21424# Environmental Science Services Administration, Boulder, Colo

REFLECTIONS FROM ELEVATED LAYERS IN TRANSHORIZON RADIO PROPAGATION

Gordon D. Thayer *In* AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 14 p refs (See N71-21409 10-07)

Avail NTIS

Computations of the power reflection coefficient R for some tropospheric elevated layers observed with radio refractometers show that the mean R varies fluctuation values from the chi to the minus 1 power dependence with standard deviations of from 3 to 14 db depend on the degree of smoothness assumed in predicting a scatter in the wavelength dependence as obtained from scaled frequency-diversity transhorizon radio experiments. The mean wavelength dependence derived from the chi to the minus 1 power model and the exact value depend on assumptions about the horizontal dimensions of individual layers compared with the size of the Fresnel zones. Published results indicate that the atmosphere consists of a mixture of large and medium layers. The randomness of the chi-dependence of real tropospheric layers makes it difficult to separate layer and turbulence mechanisms in radio propagation experiments. Author

N71-21425# Saarland Univ Saarbruecken (West Germany) Inst for Applied Physics and Electrotechnology

PROPAGATION OF AN ELECTROMAGNETIC PULSE IN A DUCT BETWEEN GROUND AND ATMOSPHERIC LAYER

K. J. Langenberg *In* AGARD Tropospheric Radio Wave Propagation Pt 1 Feb 1971 13 p refs (See N71-21409 10-07)

Avail NTIS

The influence exerted onto an electromagnetic pulse by an atmospheric surface duct is studied based on a duct model consisting of a layer of relative premittivity overlying an infinitely conducting plane earth. At the height h this permittivity decreases discontinuously to the value epsilon sub 2. The source of the electromagnetic field is assumed to be a vertical magnetic dipole above the surface of the earth with arbitrary time varying moment. The application of a Hankel transform of zero order leads to an integral representation of the Fitzgerald vector in the imaging space of a Fourier transform describing the received signal at some point in a cylindrical coordinate system. The Fourier reverse transform of the modal expansion is calculated approximately by the method of stationary phase giving a clear picture of the characteristics of an incoming signal with the aid of the group velocity concept. Author

N71-21426# Radio and Space Research Station, Slough (England)

TRANSHORIZON PROPAGATION STUDIES AT VHF AND UHF

M. P. M. Hall *In* AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 10 p refs (See N71-21409 10-07)

Avail NTIS

Measurements made to examine propagation modes producing considerable signal enhancement over the long-term median on a VHF transhorizon path are discussed. Meteorological measurements were made near the path center using a specially made radiosonde beneath a tethered balloon. Two examples are considered. On one the propagation mode changed twice within three hours, on the other the propagation mode remained constant despite a steady drop in signal of 10 dB. Author

N71-21427# Hamburg Univ (West Germany) Meteorological Inst

PROPAGATION, 16 GHz AND 17 GHz, ON A TRANSHORIZON PATH OVER SEA

H. Jeske *In* AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 10 p refs (See N71-21409 10-07)

Avail NTIS

Transmission measurements were carried out on transhorizon paths over sea at wave lengths of 1.8 cm and 4.4 cm. During the experiments the radio field strengths and the meteorological data for the determination of the propagation properties were recorded simultaneously. The dominating feature of C band propagation over sea is ducting by a permanently existing low level evaporation duct. The theoretical and experimental dependence of field strength on the thickness of this evaporation duct is discussed. The duct mechanism is clearly identified. Only occassionally (in about 15% of time) the stratification of higher layers becomes predominant. Author

N71-21428# Hamburg Univ (West Germany) Inst for Radiometeorology

DUCT INFLUENCES ON LINE OF SIGHT PROPAGATION

H. W. Fruechtenicht *In* AGARD Tropospheric Radio Wave Propagation, Pt 1 Feb 1971 9 p (See N71-21409 10-07)

Avail NTIS

The influence of surface ducts on line-of-sight propagation of electromagnetic waves is investigated by model calculations. The theoretical considerations are based on ray-tracing techniques. A linear, parabolic, and a logarithmic profile as well as a two-layer-model and a three-layer model are employed to calculate the total field. Obviously only the beam reflected at the surface of the earth gives rise to a concentration of the electromagnetic energy inside a tube-like structure near the ground. The existence of the surface duct however is by no means sufficient for the development of the focusing effect, the surface of the earth is necassary as additional reflector. The theoretical dependence of the signal strength on the duct thickness according to a three layor model corresponds with the experiment. Author

N71-21429# Research Inst of National Defence, Stockholm (Sweden)

BEYOND THE HORIZON PROPAGATION OVER SEA AT 170 AND 5000 MHz

F. Eklund, A. Blomquist, and L. Nilsson *In* AGARD Tropospheric Radio Wave Propagation, Pat 1 Feb 1971 6 p (See N71-21409 10-07)

Avail NTIS

Investigations of anomalous propagation have been made at 170 and 5000 MHz over a sea path in the Baltic area of such a length that the receiving antennas were well beyond the radio horizon. The received signals are separated into the following types: standard atmosphere signals (tropospheric scatter signal) stable and not stable signals caused by ducting or reflections in

elevated layers A comparison of the occurrence of different signal types as a function of the time of the year is given The signals at 170 and 5000 MHz are often noncorrelated, which indicates that the propagation is governed by different mechanisms The conclusion is drawn that, with regard to propagation forecasting, it is of special importance not only to predict the occurrence of elevated layers but also their effects at different frequencies
Author

N71-21430# Stanford Univ, Calif
TROPOSPHERIC INFLUENCE UPON DIFFRACTION PATHS
A T Waterman, Jr *In* AGARD Tropospheric Radio Wave Propagation Pt 1 Feb 1971 6 p refs (See N71 21409 10-07)
Avail NTIS

Two characteristics of diffraction paths are emphasized as criteria for distinguishing them from other propagation paths the presence of a physical obstacle obstructing the line of sight between transmitter and receiver and the relatively slow fluctuation rate evident in the received signal The troposphere affects signal characteristics in a variety of ways, not all of which are distinct and separable Tropospheric scatter is a competing effect when conditions are right for it to predominate, the primary result is a marked increase in fading rate Strongly refracting vertical gradients of refractive index effectively change the geometry of the path making the apparent obstacle height greater or less and shifting the regions illuminated by narrow beam antennas Phase perturbations at the diffracting aperture influence the correlation between spaced antennas and thus the optimum spacing for diversity reception
Author

N71-21431# Forschungsinstitut fuer Hochfrequenzphysik, Bonn (West Germany)
VHF PROPAGATION MEASUREMENTS ON MIXED DIFFRACTION-SCATTER PATHS
R Menzel and Kh Rosenbach *In* AGARD Tropospheric Radio Wave Propagation Pt 1 Feb 1971 10 p refs Sponsored by Min of Defence Federal Rep of Ger (See N71 21409 10 07)
Avail NTIS

Variations of diffraction link characteristics are analyzed with respect to changes in relative effects of diffraction and scatter components and due to variable meteorological conditions A basic signal analysis is undertaken and it is shown that the expected received signal consists of three components a diffraction a scatter and a reflection component Experimental data discussed deal with two main points (1) an explanation of the variations of the average received basic signal level of this link and (2) an interpretation of occasionally occuring fading The variations of the average received basic level of this mixed link correlate very closely with the variations of the ground temperature A seasonal and diurnal effect was observed A good correlation was found between fading periods the presence of upper or lower inversion layers and special wind characteristics as defined by direction and velocity
Author

N71-21432# Saarland Univ Saarbruecken (West Germany) Inst for Applied Physics and Electrotechnology
METHOD OF CALCULATING PROPAGATION OF ELECTROMAGNETIC WAVES IN AN INHOMOGENEOUS ATMOSPHERE ABOVE ROUGH GROUND
Klaus-Dieter Becker *In* AGARD Tropospheric Radio Wave Propagation Pt 1 Feb 1971 10 p (See N71 21409 10 07)
Avail NTIS

It is shown that the perturbation method for calculating the influence of roughness of the earth on the propagation of electromagnetic waves is also applicable in the case of an inhomogeneous atmosphere The method itself is described in two steps The solutions of Maxwell's equations for an inhomogeneous atmosphere are found by a method which reduces the problem to the solution of two modified wave equations These can be formally solved by the two-sided two dimensional Fourier transform The transition conditions on the rough surface of the earth are fulfilled by making a Taylor's expansion for the total field in the rough surface and by taking in account the perturbation formulation for the total electromagnetic field The new transition conditions and the radiation condition of Sommerfeld and Muller lead to a system of integral equations for the reflection and transmission coefficients of the disturbed electromagnetic field
Author

N71-21433# Centre National d Etudes des Telecommunications Issy les-Moulineaux (France) Dept EST/EFT
INTERMODULATION AND FADING DURATION DUE TO PROPAGATION (LONG WIDEBAND COMMUNICATION) [INTERMODULATION ET DUREE DES EVANOUISSEMENTS DUS A LA PROPAGATION (LIAISON LONGUE ET A LARGE BANDE)]
G H Lefrancois *In* AGARD Tropospheric Radio Wave Propagation Pt 1 Feb 1971 17 p ref In FRENCH (See N71 21409 10 07)
(ONET NT EST APH 1) Avail NTIS

The intermodulation noise during propagation of a combination hertzian beam at 6 GHz and a wideband (32 MHz) is evaluated statistically for duration and depth of fading in order to clarify the effects of these phenomena in analog and numerical modulation Obtained measurements show that intermodulation noise at median power becomes negligible before one minute because of the developing thermal noise as soon as fading passes beyond 10 db therefore the noise is not detected during qualitative analysis of the combined propagation Duration of fading follows the normal logarithmic quadradic law independent of depth
Transl by G G

N71-23451# Advisory Group for Aerospace Research and Development Paris (France)
TROPOSPHERIC RADIO WAVE PROPAGATION, PART 2
Feb 1971 366 p refs Conf held at Duesseldorf 31 Aug 4 Sep 1970 Mostly in ENGLISH, partly in FRENCH
(AGARD-CP-70-71) Avail NTIS HC$6 00/MF$0 95

The effects of tropospheric medium characteristics on radio transmission are reported Parameters of tropospheric scatter propagation and tropospheric propagation predictions are considered For individual titles see N71-23452 through N71-23474

N71-23452# Rome Univ (Italy) Electronics Inst
PROPAGATION EFFECTS OF A VARIABLE SCATTER MECHANISM
Giovanni d'Auria *In* AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 18 p refs (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

The scattering of electromagnetic waves determined by the refractive index irregularities of the troposphere is reviewed, bearing in mind its effects in radio propagation The mathematical formulation of the problem is briefly recalled both for reference purposes and in order to emphasize the meaning of the hypotheses generally assumed Particular attention in this survey is given to experimental researches contributing to a better understanding of the tropospheric scatter mechanism
Author

N71-23453# Stanford Univ Calif Electronics Labs
ANGLE AND DOPPLER MEASUREMENTS OF THE SPECULAR AND SCATTERED COMPONENTS OF TRANSHORIZON MICROWAVE SIGNALS
Nicholas Cianos and Alan T Waterman, Jr *In* AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 13 p refs (See N71-23451 12 07)
(Contract DAAB07-70-C-0138)
Avail NTIS HC$6 00/MF$0 95

A summary and interpretation of transhorizon propagation experiments at 3 2 GHz over a 164 km (102 miles) path using a modified vertical 12 element data gathering array and receiving

system is presented The measured amplitude and phase data recorded by the antenna array are processed to obtain the array angular response patterns and the signal amplitude distributions and Doppler spectra. The radio data are supplemented with refractivity and temperature profiles The occasions when strong layers are present are revealed not only by the meteorological profiles but also by the transhorizon signal Author

N71-23454# Air Force Cambridge Research Labs . Bedford. Mass
COMPARISON OF TURBULENT LAYER MODELS AND HIGH RESOLUTION FORWARD SCATTER RESULTS
Uve H W Lammers and John W B Day (Commun. Res Centre) *In* AGARD Tropospheric Radio Wave Propagation. Part 2 Feb 1971 9 p refs (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

The theoretical resolution of a long range scanning forward-scatter system has been studied assuming narrow layers of homogeneously turbulent refractivity for the tropospheric height range from 5 to 15 km Tropospheric composition, as determined experimentally through high resolution mapping techniques within the same regime is analyzed for its spatial and temporal significance The results indicate that a horizontal orientation frequently exists in the upper tropospheric structure However, this is not the general case Based on the common volume resolution and the range of the troposphere monitored, layers have been found to extend from 20 to 100 km and in rare cases up to 200 km with vertical widths from the resolution limit (0 7 km) to several kilometers On the average, the turbulent homogeneity of the scattering medium is spatially and temporally quite limited, particularly in the vertical direction Author

N71-23455# Hamburg Univ (West Germany) Inst for Radiometeorology
OBSERVATIONS WITH SYNCHRONOUSLY OFFSET BEAMS ON A 77 km PATH AT 1.8 AND 4.4 cm
H D Seehars *In* AGARD Tropospheric Radio Wave Propagation. Part 2 Feb 1971 10 p (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

Radio experiments on transhorizon links due to variations of the wavenumber vectors or displacements of the constant wavenumber vectors in space indicate the variations of the wavenumber spectrum Results of these experiments on 1 8 and 4 4 cm wavelengths point to shapes of refractive index wavenumber spectra that show a strongly marked variance, but indicate a median value close to 11/3 corresponding to the theory of Megaw-Obukhov The test of the homogeneity leads to an increase of the vertical and horizontal homogeneity with decreasing wavelength Experiments on 4 4 cm point to a vertical inhomogeneity of about 1 db/100 m Isotropy tests applied have demonstrated that there exists a weak anisotropy of turbulence which is not dependent on the frequency Author

N71-23456# Imperial Coll of Science and Technology London (England)
A STUDY OF THE EFFECTS OF TROPOSPHERIC AIR MASS MOVEMENTS ON THE FADING CHARACTERISTICS OF UHF TRANSMISSION BY THE USE OF A LABORATORY MODEL
W G Burrows *In* AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 16 p refs (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

Various types of fading characteristics obtained from a non-optical U H F link, are simulated in a simple laboratory model The fading characteristics obtained from both the real full scale system and the model are described, for the purpose of comparison by their power spectra Results are given to show that, by comparing the air mass movements created in the laboratory model to produce a particular type of fading and those which might exist for the particular meteorological conditions under which similar fading characteristics were obtained for the real full scale system, surface wind velocity is a significant parameter This result, together with the unusual observations of air mass movements in the model, suggests that near surface circulatory air mass movement along a tropospheric path can give rise to significant distortion to the shape of the transmitter beam This leads to the conclusion that transhorizon propagation in the tropospheric medium may be attributed to the effective divergence of a beam due to air mass lenses distributed along a given path Author

N71-23457# Federal German Post Office, Darmstadt (West Germany) Research Inst
METHODS OF DISTINGUISHING SCATTER AND PARTIAL REFLECTION AT TROPOSPHERIC TRANSHORIZON PATHS
L Fehlhaber *In* AGARD Tropospheric Radio Wave Propagation. Part 2 Feb 1971 14 p refs (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

Two distinct theories of tropospheric transhorizon propagation have been set up during the past years Scattering by random refractivity fluctuations and partial reflection from layer-like structures More recent investigations showed that both mechanisms exist simultaneously with varying share and that this share depends on frequency distance, altitude of the layer and on the state of the troposphere In order to investigate the problem of the sharing of the two mechanisms, a simplified model of partial reflection has been derived taking into account known tropospheric parameters This model has been worked out numerically, and it has been found to agree well with empirical data From the results it can be infered that partial reflection from finite patches of steep refractivity gradients prevails with frequencies up to 200 MHz With the higher frequencies scattering seems to predominate at all path lengths except the very short ones Author

N71-23458# Federal German Post Office Darmstadt (West Germany) Research Inst
OBSERVATIONS ON A 12 GHz SCATTER LINE OVER A 210 km PATH
N Abel *In* AGARD Tropospheric Radio Wave Propagation. Part 2 Feb 1971 9 p refs (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

Knowledge on transhorizon propagation at frequencies above 10 GHz is important in radiocommunications wherever transhorizon links are used or problems of interference between different radio systems must be solved Some first results from about one year of observations on a 12 GHz link over a 210 km path are presented In certain cases, signal types attributed to tropospheric scatter, partial reflections, or attenuation and scattering by precipitation are distinguished, although the exact share of these propagation effects was not yet determined Tropospheric scatter by far prevails and thus determines the mean transmission loss relative to free space which was found to agree well with predicted values and seems to be some decibels smaller than at 2 GHz on a similar link A correlation exists between transmission loss and atmospheric temperature near the scattering volume Author

N71-23459# Marconi Co Ltd Great Baddow (England) Research Labs
ANGLE DIVERSITY APPLIED TO TROPOSPHERIC SCATTER SYSTEMS
M W Gough *In* AGARD Tropospheric Radio Wave Propagation. Part 2 Feb 1971 16 p refs (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

The generation of substantially independent signal paths over a tropospheric scatter link by directing two or more narrow beams at different scattering regions in the troposphere makes an attractive alternative to space diversity The above factors are discussed and evaluated with the aid of a published theoretical treatment of tropospheric scattering which is well supported by experiment and careful consideration is given to the influence of

atmospheric layering It is shown how the aggregated losses enumerated above may be minimized for a specified angle diversity system by correct choice of horn feed dimensions in relation to a conventional paraboloid reflector Various two way angle diversity systems involving quadruple and six fold diversity are evaluated and their optimized performances are compared with that of a conventional space frequency quadruple diversity system using four antennas per link of like size Author

N71-23460# Saarland Univ Saarbruecken (West Germany) Inst for Applied Physics and Electronics
DEPOLARIZATION OF DIPOLE RADIATION IN A MEDIUM WITH A STATISTICALLY HOMOGENEOUS AND ISOTROPIC DISTRIBUTION OF DIELECTRIC CONSTANT
W Mohr In AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 10 p refs (See N71-23451 12-07)
Avail NTIS HC $6 00 MF $0 95

The solutions of the vector wave equation with a Hertzian dipole as source term are considered in a medium with statistically homogeneously and isotropically fluctuating permittivity For the two limits wavelength much greater or much smaller than the correlation length of the fluctuations the autocorrelation function of the depolarized part of the field is calculated by approximation methods The limit of small wavelength is treated by the perturbation method in the limit of great wavelength a renormalized dyadic Green s function is used to calculate the first term of the staircase approximation for the Bethe Salpeter equation The physical aspects of the formulas are discussed Author

N71-23461# Saarland Univ Saarbruecken (West Germany) Inst for Applied Physics and Electronics
EFFECT OF VEGETATION UPON ANTENNA PATTERN WITH SCATTER PROPAGATION ON UHF
R Zapp In AGARD Tropospheric Radio Wave Propagation Part 2 FEB 1971 7 p refs (See N71-23451 12-07)
Avail NTIS HC $6 00 MF $0 95

The pattern of an antenna radiating with a small elevation angle as used in scatter propagation is disturbed by scattering of the field at the vegetation of the antenna s foreground The vegetation can be regarded as a configuration of randomly distributed scatterers with random scattering properties The irregular motion of the vegetation caused by wind leads to similar fading and depolarization of the transmitted field as known from tropospheric scatter propagation The scatterers are described by their dielectric constants Using the perturbation expansion series are derived for the average value of the field The formalism regards the scattered field as a superposition of all the fields scattered from each scatterer of a fixed configuration The concept of randomness requires averages to be taken over a statistical ensemble of scatterer configurations Their multidimensional probability distribution is re expressed in terms of the one scatterer distributions so as to take account of coherent scattering Author

N71-23462# Michigan State Univ East Lansing
CONTROLLABILITY AND SOLVABILITY OF THE WAVE PROPAGATION IN TROPOSPHERE
M Z v Kazywoblocki In AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 12 p refs (See N71-23451 12-07)
Avail NTIS HC $6 00 MF $0 95

The fundamental concepts of the theory of optimization and controllability are reviewed and applied to the system of field equations of the wave propagation in the troposphere Then follows a brief review of other methods and a discussion on the refractive index its methods of calculation and tests Controllability in the troposcatter propagation closes the study Author

N71-23463# Signatron Inc Lexington Mass
SIGNAL DISTORTION AND INTERMODULATION WITH TROPOSPHERIC SCATTER
P A Bello L Ehrman and P Alexander In AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 18 p refs (See N71-23451 12-07)
Avail NTIS HC $6 00 MF $0 95

Multipath models used in the past for predicting the signal distorting properties of troposcatter links are reviewed The fundamental importance of the delay power spectrum in predicting signal distortion is developed in some detail Suggestions are given for improving multipath modeling by including beam bending and scintillation The concept of beam broadening as producing increased multipath is shown to be erroneous Some attention is given to relationships between multipath spread and path loss Author

N71-23464# Florida Univ Port Canaveral
FREQUENCY CORRELATION FUNCTION FOR TROPOSCATTER CIRCUITS
A M Manders In AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 17 p refs (See N71-23451 12-07)
Avail NTIS HC $6 00 MF $0 95

A mathematical model for the frequency correlation function of a tropospheric scatter channel is presented The model uses atmospheric conditions and channel parameters as inputs The results are presented in a form that allows estimation of the frequency correlation function under stable and unstable tropospheric conditions Author

N71-23465# Martin Marietta Corp Orlando Fla Communications and Electronics Div
CORRELATION BANDWIDTH MEASUREMENTS OVER TROPOSCATTER PATHS
Richard A Branham In AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 21 p refs (See N71-23451 12-07)
(Contract DAAB07 69 C 0251)
Avail NTIS HC $6 00 MF $0 95

Propagation measurements were made over four troposcatter paths simultaneous measurements of cross correlation coefficient versus frequency from zero to 9 MHz were obtained at 4 62 and 7 6 GHz in increments of 1 MHz The paths were operated cyclically for two to five week periods to obtain the effects of season terrain weather and time of day Special tests covering 200 kHz frequency increments up to 800 kHz were also made The signal strengths were recorded on magnetic tape and reduced in a digital computer to yield cross correlation versus frequency and distributions of fade durations rates signal amplitudes and fade depths Emphasis is primarily placed on the cross correlation measurements Author

N71-23466# Bell Telephone Labs Inc Holmdel N J
CHARACTERIZATION OF TROPOSPHERIC SCATTER CHANNELS BY IMPULSE RESPONSE MEASUREMENT
C C Bailey In AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 12 p refs (See N71-23451 12-07)
Avail NTIS HC $6 00 MF $0 95

A new experimental program for evaluating the transmission capabilities of the tropospheric scatter medium is reported A correlation type impulse response measurement system and a recently completed tropospheric scatter radio test link are described Results of evaluation tests of the impulse response measurement system are presented in order to indicate its measurement capabilities and the type of information which can be obtained from it Examples of experiments conducted with a troposcatter simulator and results from these experiments are given Author

N71-23467# Forschungsinstitut fuer Hochfrequenzphysik Bonn (West Germany)
CALCULATING TROPOSCATTER INTERCHANNEL

DISTORTION USING A MONTE CARLO METHOD
A Wasiljeff *In* AGARD Tropospheric Radio Wave Propagation. Part 2 Feb 1971 10 p refs (See N71-23451 12-07)
(Contract T-01012)
Avail NTIS HC$6 00/MF$0 95

Multichannel signals are simulated by sets of randomly phased sinusoids uniformly spaced in frequency The amplitudes of the sinusoids are set according to the prescribed preemphasis characteristic, some of them are set to zero to form the idle channels The signal is transformed into the time domain with the aid of fast Fourier synthesis This time signal is the modulation function for the transmitted electromagnetic field The field which reaches the receiver after having been scattered by a tropospheric volume is described with the help of an integral including the spatial Fourier transform of the autocorrelation function of the dielectric constant in the tropospheric scatter volume Analytical performance of demodulation of the calculated field in the receiver yields the distorted time function Again the fast Fourier transform is used to analyze this function The power density in the channels which had been originally idle is a measure of interchannel distortion The process is repeated with a sequence of random noise samples from each sample with a set of independent random phases The distortion is averaged to obtain the desired solution The results of the Monte Carlo method approach those obtained by measurements with Gaussian noise Author

N71-23468# Centre National d'Etudes des Telecommunications. Issy-les-Moulineaux (France)
PROPAGATION BY ATMOSPHERIC HETEROGENEITIES AND FORECAST OF ATTENUATION [PROPAGATION PAR LES HETEROGENEITES DE L'ATMOSPHERE ET PREVISION DES AFFAIBLISSEMENTS]
I Battesti and L Boithias *In* AGARD Tropospheric Radio Wave Propagation. Part 2 Feb 1971 15 p refs In FRENCH (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

A formula for calculating radio attenuation fluctuation as function of distance during propagation in a homogeneous atmospheric layer is developed that uses primary indice gradients of the transmitting volume for calculating the receiving level Considered are (1) starting angle effects as determined by angular and geographical distances, (2) intercommunication altitude effects (3) antenna gain loss characteristics, (4) distance, climate and starting angle effects on antenna gain loss, (5) a limiting law for gain loss in high resolution antennas, and (6) effects of antenna gain characteristics, distance and starting angles on transmissible bandwidth
Transl by G G

N71-23469# AEG-Telefunken, Backnang (West Germany) Dept of Radio Link Systems
PROPAGATION CHARACTERISTICS OF TROPOSPHERIC SCATTER RADIO LINKS IN THE 5 GHz RANGE WITH RESPECT TO PATH LOSS PREDICTIONS
Klaus Radermacher and Guenther Rappallier *In* AGARD Troposphere Radio Wave Propagation, Part 2 Feb 1971 10 p refs (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

Planning of stationary and use of mobile tropospheric scatter systems require prediction methods of tropospheric scatter losses for links in all climate Prediction methods are considered as to their application and compared to the current state of knowledge in the field of tropospheric scatter propagation Test results obtained by field testing a new mobile tropospheric scatter system, operating in the band about 4 5 GHz on four paths are compared with predictions The test results were apparently at times adversely affected by anomalous weather conditions Frequency saving operation with quadruple space diversity using two polarizations is possible Author

N71-23470# Forschungsinstitut fuer Hochfrequenzphysik Werthhoven (West Germany)
DAILY AND HOURLY FORECAST OF TROPOSPHERIC PROPAGATION PARAMETERS
H J Albrecht *In* AGARD Tropospheric Radio Wave Propagation. Part 2 Feb 1971 12 p refs Supported by Min of Defence, W Germany (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

The present state of the art of daily and hourly forecasts of tropospheric propagation parameters, on the basis of research work known at this juncture is summarized In accordance with the subject matter, frequent reference is made to meteorological conditions and their predictions Following analyses on propagation aspects and their predictability, meteorological aspects as well as the predictability for specified telecommunication links are considered
Author

N71-23471# Forschungsinstitut fuer Hochfrequenzphysik Werthhoven (West Germany)
SHORT TERM FORECAST OF SIGNAL BEHAVIOUR WITH TROPOSPHERIC SCATTER LINKS
D E Marquart *In* AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 49 p refs (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

Forecasts of signal attenuation with tropospheric scatter links by means of meteorological values have shown that considerable increases of signal attenuation correlate with the passage of cold fronts through the scatter volume and that the intensity of this signal decrease is related to the age of the front Considered is the present state of research work with particular attention on the interpretation of correlation results a detailed comparison between predicted and observed signal behavior is presented In addition, signal enhancements and their possible forecasts on the basis of the occurrence probability of super-refraction layers is dealt with Other parameters determining general signal behavior are also treated Author

N71-23472# Institute for Telecommunication Sciences, Boulder, Colo
PREDICTION OF TROPOSPHERIC RADIO TRANSMISSION LOSS OVER IRREGULAR TERRAIN
A G Longley and P L Rice *In* AGARD Tropospheric Radio Wave Propagation, Part 2 Feb 1971 8 p refs (See N71-23451 12-07)
Avail NTIS HC$6 00/MF$0 95

A method for calculating long term median radio transmission loss over irregular terrain at frequencies above 20 MHz is described The model is particularly useful for area predictions of transmission loss as a function of distance, frequency, antenna heights, and terrain characteristics where individual path profiles are not known Such predictions are needed for military communication and surveillance, for land mobile, broadcasting, and air-to-ground systems, and for calculating preliminary performance estimates for system design The prediction model summarizes much of our present knowledge of tropospheric propagation theory and has been tested against measurements over a wide range of distances, for frequencies from 20 to 10 000 MHz, for terrain types ranging from smooth plains to rugged mountains, and with antenna heights ranging from very low to aircraft heights Author

N71-23473# Lockheed Electronics Co West Long Branch, N J
STATISTICAL PROPAGATION MODEL FOR IRREGULAR TERRAIN PATHS BETWEEN TRANSPORTABLE AND MOBILE ANTENNAS
J P Murphy *In* AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 21 p refs (See N71-23451 12-07)
(Contract DAAB07-67-C-0104)
Avail NTIS HC$6 00/MF$0 95

A statistical model of tropospheric radio propagation loss that can be used by ground mobile radio communications systems

designers without the aid of a computer program is developed. Such a model provides a first order estimate of median values and standard deviation values of basic transmission loss for path over a particular type of terrain based on the assumption that path-to-path variability of basic transmission loss is close to that of a normal distribution in decibels. The method used to develop the model is closely related to the one used to develop the Egli model for radio propagation above 40 MHz over irregular terrain. The data used to develop the model have been measured on paths between antennas that are transportable and antennas that are mobile. The only independent parameters used are signal frequency, antenna heights and path distance.
Author

N71-23474# Hamburg Univ (West Germany) Meteorological Inst

THE STATE OF RADAR RANGE PREDICTION OVER SEA

H Jeske *In* AGARD Tropospheric Radio Wave Propagation Part 2 Feb 1971 11 p refs (See N71-23451 12-07)
Avail NTIS HC$6 00/MF $0 95

The methods of radar range prediction of marine cm radars are closely related to the boundary layer theory for the propagation conditions are governed by the low level evaporation duct in 85% of time. Over a wide range of atmospheric stability the logarithmic profile with a stability-dependent profile coefficient yields a good correlation between radio field strength and duct thickness. For strong deviations from the neutral equilibrium however more complicated profile forms are employed.
Author

N72-16085# Advisory Group for Aerospace Research and Development, Paris (France)

PROPAGATION LIMITATIONS IN REMOTE SENSING

John B Lomax, ed (Stanford Res Inst, Menlo Park, Calif) Oct 1971 424 p refs Presented at the 17th Symp of the Electromagnetic Wave Propagation Panel of AGARD Colorado Springs, Colo 21-25 Jun 1971 Original Contains Color Illustrations
(AGARD CP-90-71) Avail NTIS HC $6 00/MF $0 95

Theoretical and experimental performance analyses are reported for various remote sensing systems in order to develop their propagation ranges and suitabilities in relation to investigated media. Results cover the spectrum from optical to radio frequencies. For individual titles, see N72-16086 through N72-16119

N72-16086# Army Engineer Topographic Labs Fort Belvoir Va

A PROGRAM FOR THE DEVELOPMENT OF ADVANCED CAPABILITIES FOR COLLECTION, ANALYSIS, PRODUCTION AND DISSEMINATION OF MILITARY GEOGRAPHIC INTELLIGENCE

Kenneth R Kothe *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 36 p (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

The objectives of the R&D program are identified as collection systems, data reduction systems and information systems. To improve data collection capabilities, work is described associated with sidelooking airborne radar and color multiband photographic systems. To improve the data reduction, research and development leading to automated image data extraction capability is reviewed. Then the development of a military geographic information system with an example output is outlined in relation to an overall concept. In conclusion, it appears the research and development objectives can be attained to implement the concept of operations in the 1985 time frame.
Author

N72-16087# Army Engineer Topographic Labs, Fort Belvoir Va

PROJECT SAND REMOTE SENSING FOR ENGINEER CONSTRUCTION MATERIALS

Donald G Orr and James R Quick *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 17 p refs (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

Remote sensor flights have been conducted over areas in the Mississippi Delta to determine the sensor configuration, analysis techniques, and diagnostic criteria for locating engineer construction materials under Project Sand. The sensor utilized included photography, thermal infrared, and sidelooking radar. In addition to the aerial imagery acquisition, ground measurements were made in each of the areas under investigation. The sensor imagery and ground truth data were analyzed by a team of experts in various earth science disciplines. The airborne operations and field data collection are described and a summary of the analyses results with unclassified illustrations are presented.
Author

N72-16088# Development and Resources Transportation Co, Silver Spring, Md

AUTOMATIC PROCESSING OF ARCTIC PACK ICE DATA OBTAINED BY MEANS OF SUBMARINE SONAR AND OTHER REMOTE SENSING TECHNIQUES

Leonard A LeSchack, William D Hibler III (Army Cold Reg Res and Eng Lab, Hanover, N H), and Frederick H Morse (Maryland Univ College Park) *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 19 p refs Original Contains Color Illustrations (See N72-16085 07-07)
(Contract N00014-70-C-0110 NR Proj 307-322)
Avail NTIS HC $6 00 MF $0 95

Three remote sensors have been used for examining the upper and under surface of the Arctic ice pack, an upward looking sonar mounted on a nuclear submarine transiting beneath the ice producing an under ice profile, a vertically mounted airborne laser producing an upper ice surface profile and an airborne infrared scanner in the 8-14 micron range producing a heat picture of the ice surface. The sonar data were digitized and analyzed. Frequency distribution of amplitudes of the profile data indicates that young ice has a sharp, uni-modal distribution, older more jumbled ice has a broad based uni-modal distribution and old, much ridged ice has a bi-modal distribution. The same analytical techniques were used to process airborne laser profile data of pack ice. Analysis of profiles of multi-year ice and young ice show that the young ice has greater amplitude of all ridge spacings shorter than 20 m than does the multi-year ice. Airborne infrared scanning imagery of pack ice was color contoured using a spatial data system. A simplified energy balance equation was used as a method to determine thickness of ice scanned.
Author

N72-16089# Communications Research Centre Ottawa (Ontario)

THEORY AND FIELD TESTS OF A MICROWAVE RADIOMETER FOR DETERMINING SEA ICE THICKNESS

A W Adey *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 10 p refs (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

A theoretical analysis of UHF emissions from sea ice and open water is outlined. A radiometer system designed to observe these emissions operating at frequencies from 400 MHz to 1.1 GHz has been designed and built. The results of initial ground based and airborne tests of this instrument are presented. Initial results tend to confirm the theoretical analysis and predictions.
Author

N72-16090# Kansas Univ, Lawrence Remote Sensing Lab

RADAR IMAGING APPLICATIONS PAST, PRESENT, AND FUTURE

Richard K Moore *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 13 p refs (See N72-16085 07-07)
Avail NTIS HC $6 00 MF $0 95

Some of the proven applications of radar are outlined and future applications are suggested. Although restricted mostly to imaging systems, brief mention is made of the application of

non-imaging radars to determining wind speeds over the oceans. Applications to be include geology, geography, hydrology, bio-geography (including agriculture), oceanography, and cartography Author

N72-16091# Louisiana State Univ., Baton Rouge. Dept. of Geography and Anthropology
CUMULATIVE FREQUENCY CURVES OF THE DARIEN PROVINCE, PANAMA
Anthony J. Lewis and William Waite (Arkansas Univ.) *In* AGARD Propagation Limitations in Remote Sensing Oct. 1971 10 p (See N72-16085 07-07)
Avail: NTIS HC $6.00/MF $0.95

Histograms and cumulative frequency curves of terrain slope are important in the quantitative description of geomorphic regions and aid in the study of land utilization and terrain mobility. Recently a method for obtaining such terrain slope information from radar imagery was developed utilizing the necessary relationship between terrain slope and the depression angle for the occurrence of radar shadows and the variation in depression angle from near to far range across the radar image. The characteristic shape of the cumulative frequency curves for four general geomorphic regions in Panama--plains, low hills, high hills, and mountains--proved diagnostic and substantiated both the qualitative geomorphic boundaries and the quantitative slope data determined from radar imagery. Only quantitative regional slope information is available for the poorly mapped Darien area in Panama Author

N72-16092*# Kansas Univ., Lawrence. Dept. of Geography
VEGETATION MAPPING WITH SIDE LOOKING AIRBORNE RADAR: YELLOWSTONE NATIONAL PARK
Norman E. Hardy, Jerry C. Coiner, and William O. Lockman *In* AGARD Propagation Limitations in Remote Sensing Oct. 1971 19 p refs (See N72-16085 07-07)
(Contract NAS9-10261)
(NASA-CR-125451) Avail: NTIS HC $6.00/MF $0.95 CSCL 08B

The purpose of this study is to delimit the vegetation communities of Yellowstone National Park to the greatest extent possible by interpreting SLAR imagery and to identify factors which could be modified or controlled to enhance information content for any future SLAR vegetation mapping projects. The interpretation approach to the SLAR imagery was first to define the boundaries of the vegetation communities. After boundary definition, a classification of vegetation types was established based upon elevations, moisture and slope features evident in the SLAR image. To assist in the classification of the vegetation communities, a matrix interpretation key was constructed. Comparison of the vegetation map developed from SLAR and that prepared from ground truth data points to the ability of an active microwave image to provide vegetation information at the community level Author

N72-16093# Physics Lab. RVO TNO, The Hague (Netherlands)
THE RADAR BACKSCATTER OF VEGETATION
G. P. deLoor and A. A. Jurriens *In* AGARD Propagation Limitations in Remote Sensing Oct. 1971 7 p refs (See N72-16085 07-07)
Avail: NTIS HC $6.00/MF $0.95

To study the possible use of image tone in SLAR imagery for inventory purposes, a series of measurements were performed at X band (and some at Ka band) on the backscatter coefficients of single fields in an agricultural area through a complete growing season. Use was made of a static platform with the radar at an altitude of 75 m above the terrain. The influence of the weather on the backscatter coefficient is studied by comparing the measurements with the output of an automatic weather station Author

N72-16094# Naval Research Lab., Washington, D.C. Hulburt (E. O.) Center for Space Research.
WAVE HEIGHT MEASUREMENTS WITH A NANOSECOND RADAR
B. S. Yaplee, A. Shapiro, D. L. Hammond, and E. A. Uliana *In* AGARD Propagation Limitations in Remote Sensing Oct. 1971 13 p ref (See N72-16085 07-07)
Avail: NTIS HC $6.00/MF $0.95

A radar system has been developed with a sufficiently narrow pulse width to resolve the vertical wave structure of ocean waves. The radar illuminates a 70 cm diameter spot on the ocean at normal incidence and three wave poles are placed in a delta configuration around the spot for ground truth measurements. A corner reflector is placed at the center of the antenna beam to calibrate radar measurements both in range and amplitude. Wind conditions are monitored using the tower's anemometer. These ground truths are then used in relating the radar measurements to actual sea conditions. The wave heights encountered range from two to six feet. Results of the radar measurements are presented and compared with simultaneous wave pole measurements of the sea surface structure Author

N72-16095# Naval Research Lab., Washington, D.C.
REMOTE PASSIVE MICROWAVE MEASUREMENTS OF THE SEA SURFACE
James P. Hollinger *In* AGARD Propagation Limitations in Remote Sensing Oct. 1971 7 p refs (See N72-16085 07-07)
Avail: NTIS HC $6.00/MF $0.95

The important potential of all weather determination of ocean surface wind fields by means of remote passive microwave sensing is discussed. The wind speed dependence of the microwave brightness temperature of the sea is interpreted as resulting primarily from small scale wave structure at wind speeds below about 15 to 20 m/sec and from the increasing coverage of sea foam at higher wind speeds. Measurements of these two effects are presented and the characteristics of each described separately. The two effects are combined to estimate the total microwave brightness temperature dependence of a wind driven sea as viewed from a satellite. Taken together the two effects allow the determination of ocean surface wind fields over the entire range of wind speeds Author

N72-16096# Naval Research Lab., Washington, D.C.
REMOTE SENSING OF OCEAN EFFECTS WITH RADAR
N. W. Guinard *In* AGARD Propagation Limitations in Remote Sensing Oct. 1971 12 p refs (See N72-16085 07-07)
Avail: NTIS HC $6.00/MF $0.95

Remote sensing of ocean surface effects is reported with the objective of evolving theoretical models of these effects to aid systems design and the acquisition of data in situ and in laboratory simulations to determine appropriate parametric relationships. The four frequency radar system, a calibrated airborne measurement facility, has been extensively used for the in situ data collection. The radar is capable of operating sequentially on X band (8910 MHz), C band (4455 MHz), L band (1228 MHz) and P band/UHF (428 MHz) with both horizontal and vertical polarization. A review of the theoretical models and the parametric relationships is presented. In the course of the study, two new techniques for remotely sensing wave spectra have been evolved and used to obtain an explanation for the wavelength dependence of the sea return in low wind fields Author

N72-16097# Forschungsinstitut fuer Hochfrequenzphysik, Werthhoven (West Germany)
PROPAGATION EFFECTS ON MONITORING ATMOSPHERIC FINE STRUCTURE USING SIDE SCATTER ON APPROPRIATE FREQUENCIES
H. J. Albrecht and M. Piening *In* AGARD Propagation Limitations in Remote Sensing Oct. 1971 7 p refs (See N72-16085 07-07)
Avail: NTIS HC $6.00/MF $0.95

The possibilities of extending side scatter analysis to higher frequencies are examined with regard to the very timely subject of monitoring air pollution above industrial areas, cities, and other exposed areas. The limits of detecting appropriate element

sues as well as the combination of such methods with turbulence analysis by side scatter are considered for the purpose of estimating the degree of danger and its variation
Author

N72-16098# Fengler (C) Hamburg (West Germany)
REMOTE SENSING AND ATMOSPHERIC LAYERS
C Fengler *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 8 p refs (See N72 16085 07 07)
Avail NTIS HC $6.00/MF $0.95

Since absorption and scattering are well-known effects for the propagation limitations in remote sensing by electromagnetic waves refraction, reflection as well as ducting effected by atmospheric layers are considered The reflection coefficient of Epstein profiles is treated in order to illustrate the effect of total reflection by grazing incidence The deflection from a concentric layer of rays starting at the earth's surface and of rays coming from the outside of the earth is considered The theoretical treatment is completed by presenting results of measurements of an earth - earth radio link as well as of a space - earth radio link evaulated under the aspect of the tropospheric layer structure
Author

N72 16099# Wisconsin Univ Middleton Geophysical and Polar Research Center
ELECTROMAGNETIC SOUNDING OF ICE THICKNESS
C R Bentley and J W Clough *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 7 p refs (See N72 16085 07 07)
Avail NTIS HC $6.00 MF $0.95

The efficiency of ice thickness determination in Antarctica and elsewhere has been vastly improved by the use of electromagnetic sounding The electromagnetic sounder which is basically a low frequency radar system is easily adapted to use in an aircraft and is capable of measuring thicknesses of ice as great as 4 km Since pure ice has an extremely low conductivity electromagnetic wave propagation at a frequency of around 35 MHz is essentially non dispersive Absorption takes place in close accordance with the high frequency tail of a Debye relaxation spectrum and is highly temperature dependent the attenuation factor varying by 50 100 db km over the range of temperatures (about 60 C) found in different glaciers The attenuation in very cold ice is so small that it is substantially less than the normal spherical spreading loss Losses occurring at the reflecting boundary are about 10 20 db for most earth materials but may be more if the boundary is rough At a sharp ice sea water boundary however the reflection loss is only 0.5 db
Author

N72 16100# Army Engineer Topographic Labs Fort Belvoir Va
A MATHEMATICAL ANALYSIS OF THE PROPAGATION AND REFLECTION OF PLANE ELECTROMAGNETIC WAVES IN A NONHOMOGENEOUS ISOTROPIC MEDIUM
Richard A Hevenor *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 9 p refs (See N72 16085 07 07)
Avail NTIS HC $6.00 MF $0.95

Understanding of the propagation of electromagnetic waves in natural terrain surfaces can be aided by solving the vector wave equation for the case when the conductivity the dielectric constant and the magnetic permeability are functions of soil depth The problem to be analyzed is that of a nonhomogeneous half space where the conductivity and dielectric constant are arbitrary functions of depth The basic approach employed is that of the geometrical optics solution of the wave equation The final results yield expressions for the magnitude and phase of an electromagnetic field propagating in the nonhomogeneous medium for horizontal and vertical polarizations
Author

N72 16101# Naval Electronics Lab Center for Command Control and Communications, San Diego Calif
REMOTE SENSING OF TROPOSPHERIC STRUCTURES USING HIGH RESOLUTION RADAR
J H Richter, E E Gossard and D R Jensen *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 13 p refs (See N72 16085 07 07)
Avail NTIS HC $6.00/MF $0.95

A very sensitive ultra high resolution radar has been developed for the purpose of studying the refractive index structure of the troposphere The radar is a ground based vertically pointing FM CW radar with a range resolution of one meter The radar and its performance characteristics are described The radar routinely detects layer structures in the lower troposphere These layers are always associated with gradients in the vertical refractive index profile and are frequently very thin approaching the resolution of the radar Very often they are perturbed by wave motions Examples of various wave patterns are presented
Author

N72 16102# Wisconsin Univ Middleton Geophysical and Polar Research Center
EFFECT OF BEAM WIDTH ON ACOUSTIC SIGNALS SCATTERED AT A ROUGH SURFACE
C S Clay and G A Sandness *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 8 p refs (See N72 16085 07 07)
Avail NTIS HC $6.00 MF $0.95

Underwater acoustic experiments were made in a laboratory tank in which the signals were scattered at a wind blown surface The rms roughness and spatial correlation function of the surface were measured by wave height probes The ratio of the mean rectified signal scattered at the rough surface and that reflected at the smooth surface was measured for vertical incidence Even though the surface was rough the mean rectified signal was inversely proportional to the source distance plus receiver distance At large roughness the reflection scattering function depends upon beam width and tends to the usual plane interface reflection function
Author

N72 16103*# National Aeronautics and Space Administration Manned Spacecraft Center Houston Tex
INFRARED AND MULTISPECTRAL REMOTE SENSING
M R Holter *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 13 p refs Original Contains Color Illustrations (See N72 16085 07 07)
(NASA TM X 67496) Avail NTIS HC $6.00 MF $0.95 CSCL 14B

The history of infrared from its discovery in 1800 by Herschel is sketched Recent advancements are described leading to modern infrared remote sensing devices The performance of such devices is illustrated and future directions of development outlined The recent extension of the infrared scanner to the multispectral sensing and pattern recognition system is described Results from such systems are shown limitations in their utility due to lack of understanding of signatures are described and likely future developments are outlined
Author

N72 16104# Electronique et de Physique Laboratoire d Appliquees Paris (France)
FUNDAMENTAL AND PRACTICAL LIMITS OF REMOTE INFRARED IMAGING INSTRUMENTS OPERATING BETWEEN 2.5 AND 18 MICRONS c14
F Desvignes *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 14 p refs In FRENCH, ENGLISH summary (See N72 16085 07 07)
Avail NTIS HC $6.00/MF $0.95

Main advantages of infrared radiation for remote sensing are outlined and the relations between space time and signal level resolving power of the instruments are considered in the propagation affects of signal attenuation and stray radiation An analysis of the hypothesis and results of a computation of overall atmospheric transmittance for instruments using various types of detectors are given This computation takes into account the absorption and diffusion by gases and aerosols in horizontal propagation versus the distance
Author

N72-16105# Lille Univ (France) Lab d'Optique Atmospherique
ANALYSIS OF RADIOMETRIC INFRARED SEA TEMPERATURE MEASUREMENTS
P Y Deschamps, P Lecomte, and J C Vanhoutte *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 9 p refs In FRENCH (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

Correction procedures are described that provide real temperature data for a sea surface from infrared radiometric measurements The primary error source is reflection of sky radiation from the surface, it is corrected by real measurements at sea level The secondary error is caused by transmission through the air layer between the radiometer and the sea, it is corrected theoretically Above described corrections provide absolute temperature values for the sea surface with an accuracy of about 0 1 degree Transl by G G

N72-16106# Lille Univ (France) Lab d'Optique Atmospherique
ANALYSIS OF RADIOMETRIC INFRARED MEASUREMENTS ON CLOUD TEMPERATURES AND STRUCTURES
Y Fouquart and J Lenoble *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 8 p refs In FRENCH (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

The angular distribution of radiation intensity in a cloudy atmosphere is studied by the 4 3 micron carbon absorption band Evaluation of the observed spectral frequencies shows that radiation transmission depends on the optical thicknesses of cloud layers Transl by G G

N72-16107# National Environmental Satellite Center, Washington, D C
FACTORS AFFECTING THE ACCURACY OF SEA SURFACE TEMPERATURE MEASUREMENTS FROM ITOS-SR DATA
J Leese, W Pichel, B Goddard, and R Brower *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 13 p refs (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

The improved TIROS satellite sensor package contains a two channel scanning radiometer which operates in the 52- to 73-micron visible range and the 10 5- to 12 5-micron infrared water vapor window One of the primary applications of the IR data is the operational determination of global sea surface temperatures The objective is to make statistically-integrated measurements over areas approximately 100 km on a side, which agree with ground truth measurements within a root-mean-square deviation no larger than 1 C A quantitative error analysis of the ITOS system, combined with tests on real data, shows that the objective should be reached using only IR data in regions where the magnitude of the temperature gradient is less than 2 C per 100 km In regions where the temperature gradients are 2 to 4 C per 100 km the inclusion of SR data from the visible channel to reduce cloud contamination errors should place the accuracy objective within accessible limits Author

N72-16108# Atmospheric Sciences Lab, White Sands Missile Range, N Mex
ERBIUM LASER PROPAGATION IN A CO2 ATMOSPHERE IN THE NEAR INFRARED
Kenneth O White, E Howard Holt, Stuart A Schleusener (New Mex State Univ, Las Cruces), and Robert F Calfee (NOAA, Boulder, Colo) *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 5 p refs (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

The transmission of laser energy in a carbon dioxide atmosphere has been measured in the 1 54 micrometers spectral region An erbium laser was used which had two output emission regions in the eye-safe realm of the spectrum The CO2 sample was contained in a pressure and temperature controlled 20 m, White cell The monitor and transmitter laser pulses were detected by germanium photodiodes and recorded on a dual parameter pulse-height analyzer which provided a real-time indication of the transmission and the quality of the data A spectral scan over the laser output was obtained by sending a portion of the laser beam through a 3 3 m grating spectrometer which was preset to a narrow spectral region within one of the two output regions of the laser The spectrometer was scanned over the laser output and the transmission obtained as a function of wavelength Data and theoretical calculations are presented for a 480 m path length, a temperature of 30 C, and a CO2 pressure of one atmosphere Author

N72-16109# Kansas Univ, Lawrence Center for Research, Inc
EFFECT OF ANGULAR VARIATION ON TERRAIN SPECTRAL REFLECTIVITY
Dwight D Egbert and Fawwaz T Ulaby *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 10 p refs (See N72-16085 07-07)
(Contract DAAK02-68-C-0089)
Avail NTIS HC $6 00/MF $0 95

A technique is described that determines the optimum filter combinations and the feasibility of multiband photography in the visible and near infrared regions in planning remote sensing missions The test provides multispectral reflectivity curves not only for targets to be identified, but also for those backgrounds against which they are encountered The procedure incorporates a method for determining spectral reflectance as a function of solar altitude, incidence look angle, and azimuth look angle This angular dependence of reflectivity is significant and an aid in detecting certain targets It was found that for one target-background pair (asphalt and grass) the contrast ratio ranges from 2 1 to 0 5 1 under different angle conditions Author

N72-16110# Army Engineer Topographic Labs, Fort Belvoir, Va
THE USE OF COLOR AERIAL PHOTOGRAPHY IN THE RECONNAISSANCE OF SOILS AND ROCKS
Abraham Anson *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 10 p refs (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

A specialized interpretation of soils and rocks can be obtained from aerial photography in color In using aerial color film, the three-layer emulsion presents a more readily understood spectral relationship than can be obtained from black-and-white film, the reconnaissance of inaccessible areas with their rock structures is more rapidly analyzed than solely by ground exploration Geologists analyze soil conditions using 1 20,000 scale aerial color and infrared photographs together with sparse generalized ground information Author

N72-16111# Kansas Univ, Lawrence Dept of Geography
AN ANALYSIS OF MULTISPECTRAL IMAGERY FOR TROPICAL LAND USE DISCRIMINATION
Roland D Mower *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 16 p refs (See N72-16085 07-07)
(Contract DI 14-08-0001-12077)
Avail NTIS HC $6 00/MF $0 95

Imagery data from a number of flight lines over Puerto Rico were analyzed to determine to what extent selected land use classes could be discriminated using conventional image interpretation techniques The results were then compared with those obtained through use of a semi-automated densitometer/computer process The semi-automated technique was also employed to determine which of the nine imagery channels (Ektachrome blue, green, red, and IR, multiband blue, green red and IR, and IR scanner) provides the best discrimination for each of the land use classes considered A number of tentative conclusions were made regarding the relative performance of the imagery channels tested Author

N72-16112# TRW Systems Group Redondo Beach Calif
SEA BRIGHTNESS TEMPERATURES AT MICROWAVE FREQUENCIES

R J Wagner and P J Lynch *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 16 p refs (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

A complete geometrical optics theory of rough-surface emission and scattering is developed which accounts explicitly for surface shadowing effects and the contributions of double-scattered radiation The validity of the emission theory is tested by comparing the results with a case for which the exact solution is known A theorem is proved which establishes, for the domain of geometrical optics, the existence of rigorous upper and lower bounds to the effects of surface roughness on brightness temperatures the Peake representation yields the upper bound provided shadow corrections, at least, are included, while an alternative representation provides the lower bound Microwave brightness temperatures for the sea are calculated for a cylindrical roughness model Double scatter contributions are shown to be appreciable and, with their inclusion, accurate calculation of brightness temperatures is possible A model for a wind driven spray layer is integrated into the theory and semi-emprical corrections for foam added, the results agree well with rough-sea data Author

N72-16113# Air Force Cambridge Research Labs , Bedford Mass

STATISTICAL METHODS OF INDIRECT PROBING OF THE ATMOSPHERE

V J Falcone, Jr and K Mano *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 5 p refs (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

Three statistical methods for inversion of the radiative transfer equation (or any Fredholm integral equation of the first kind) are examined For the microwave region of the electromagnetic spectrum the unknown function to be determined under the integral of the radiative transfer equation is the atmospheric temperature Westwater and Strand determine the temperature profile by applying linear estimation theory Tikhonov on the other hand assumes a smoothing functional which is minimized by the Euler Lagrange equation These two methods are shown to be equivalent when appropriate identification of terms is made, and where the regularization term of the smoothing functional is a linear differential operator This equivalence is shown by use of Bayes estimation which is equivalent to the linear estimation theory and in which the same functional form as the smoothing functional is minimized Author

N72-16114# Office National d Etudes et de Recherches Aerospatiales, Paris (France)

IMAGE ANALYSIS BY MULTIPLEX CODING

Andre Girard *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 15 p refs In FRENCH, ENGLISH summary (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

An incohernet radiation distribution is analyzed by means of a system whose radiation transducer is a flux detector receiving incoming signals in a coded form The coding presents the characters of a multiplex method, it insures the optimum use of the available time to analyze the distribution under study as the flux detector receives during the whole analysis time the radiation issued from all the elements of the space function A gain in the signal/noise ratio is thus obtained as compared to direct analysis methods The spectral range considered is in the infrared region According to the first experimental results obtained the use of pseudo random binary cyclic codes seems the best in view of the practical advantages they offer Author

N72-16115# Max Planck Institut fur Aeronomie, Lindau Uber Northeim (West Germany)

AN APPLICATION OF THE MONTE CARLO METHOD TO REMOTE SENSING SYSTEMS

J Roettger *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 10 p refs (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

The reliability of remote sensing systems, making use of electromagnetic wave propagation, is considerably influenced by propagation limitations due to the varying refractive index of the passed and sensed medium Monte Carlo calculations, simulating an experiment by statistical computer mathematics, are carried out for ionospheric off-great circle propagation on the transequatorial radio path Lindau/West Germany Tsumeb South West Africa These calculations yield information about the error probability and reliability concerning the determination of sidereflection areas in the equatorial zone, using probability distributions of the parameters of ionospheric wave propagation Statistical tests prove that the results, computed from remote measured data by means of a Monte Carlo technique, agree sufficiently well with direct measurements at the equator Author

N72-16116# Michigan State Univ , East Lansing

TURBULENCE AND REFRACTIVITY CHANGES AND THEIR SENSING BASED UPON THE WAVE MECHANICS THEORY

M Z V Krzywoblocki *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 10 p refs (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

Some methods of the quantum field theory in statistical physics are applied to a Bose type of medium fluid The application of the wave mechanics theory to a spatial domain in a turbulent field is outlined and the propagation of waves in a turbulent medium is formulated by the Tatarski method This is accompanied by a discussion of wave scattering in the turbulent atmosphere as well as of the influence of the turbulent field upon the magnitude and the variation of the refractive index for radio waves Successful application of the concept of remote sensing to the status of atmospheric turbulence and refractivity variations is shown Author

N72-16117# Kansas Univ Lawrence Center for Research, Inc

ON BACKSCATTERING FROM TWO SCALE ROUGH SURFACES

A K Fung and H L Chan *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 13 p refs (See N72-16085 07-07)
(Contract NAS1-10048)
(NASA-CR-125452) Avail NTIS HC $6 00/MF $0 95 CSCL 20N

The two scale composite rough surface model usually considered is one made up of large undulations over which small irregularities are superimposed This general model may be further subdivided into two other models (1) the large undulations are larger in dimension than that of the illuminated area so that within the beam of illumination the picture is a tilted perturbed plane and (2) the large undulations are of such a size that at least several undulations can be found within the beam The first model is essentially the small perturbation model The second model is much more complicated the contribution from the small irregularities may be computed by summing powers from the large facets constituting the large undulations The total contribution from the composite surface is then taken to be that from the large undulations plus that from the small irregularities averaged over the large undulations If the non coherent assumption is not made the total scattered field from the illuminated area must be computed before evaluating the power This is the approach adopted by this paper to calculate both the vertically and horizontally polarized scattering coefficients Author

N72-16118# Wisconsin Univ Madison Dept of Electrical Engineering

THE IDENTIFICATION OF INHOMOGENEOUS MEDIA FROM TRANSIENT DIFFUSION OF ELECTROMAGNETIC FIELDS

J N Towle *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 9 p refs (See 16085 07-07)
(Grants NSF GK-2311 NSF GK-21218)
Avail NTIS HC $6 00/MF $0 95

For the purposes of magneto-telluric exploration the penetration of electromagnetic energy into the conducting strata presented by the earth's crust may be described by the parobolic equation of diffusion with a spatially dependent coefficient A difference-differential solution to this equation is implemented on a hybrid computer and the resulting time dependent solutions are studied Boundary conditions of the Neumann type, corresponding to the specification of magnetic field on the boundary, are appropriate for the determination of electric field in the conducting medium. The additional boundary conditions imposed by specification of electric field on the boundary provides the necessary information for the synthesis of a previously unknown conductivity profile Author

N72-16119# Kansas Univ. Lawrence
WORKSHOP ON RADAR SCATTERING HELD TUESDAY AFTERNOON 22 JUNE 1971
R K Moore *In* AGARD Propagation Limitations in Remote Sensing Oct 1971 7 p (See N72-16085 07-07)
Avail NTIS HC $6 00/MF $0 95

Three topics are discussed Radar backscatter from the sea, the need for microwave data on dielectric properties of natural surfaces and objects, and slant-range measurements by the nanosecondpulse radar The most significant conclusion to emerge is that insufficient data are available on the dielectric constants of natural materials (ice, vegetation, soil) measured in situ Author

N72-21121# Advisory Group for Aerospace Research and Development. Paris (France)
RADAR PROPAGATION IN THE ARCTIC
Jon Frihagen. ed Jan 1972 430 p refs Presented at Specialists Meeting of the Electromagnetic Wave Propagation Panel of AGARD, Lindau/Harz, West Germany 13-17 Sep. 1971
(AGARD-CP-97) Avail NTIS HC $8.00/MF $0 95

The characteristics and effects of the Arctic ionosphere on radio and radar propagation are considered Experimental and theoretical efforts in the field are reviewed. For individual titles, see N72-21122 through N72-21153

N72-21122# Communications Research Centre, Ottawa (Ontario)
MORPHOLOGY OF RADIO-RADAR POLAR PROPAGATION EFFECTS
T R Hartz *In* AGARD Radar Propagation in the Arctic Jan 1972 18 p refs (See N72-21121 12-07)
Avail NTIS HC $6 00/MF $0 95

A variety of observational data are reviewed for the polar upper atmosphere, and particularly for morphological patterns deduced for particle precipitation associated with auroral phenomena and with polar cap disturbances The significance of different portions of such patterns are discussed with reference to particle energies, sources, and ionospheric changes during disturbed intervals Statistical data are given on the diurnal, seasonal, and spatial variation of such associated propagation effects as absorption, scintillation, dispersion etc, along with their correlation with magnetic activity, spread F, sporadic E visual aurora, and radio noise observations In addition, the storm time variation of some of these phenomena are discussed from the point of view of their short term effects on radio wave propagation Author

N72-21123# Air Force Cambridge Research Labs L G Hanson Field, Mass
ON MODELLING THE ARCTIC IONOSPHERE
G J Gassman *In* AGARD Radar Propagation in the Arctic Jan 1972 C p refs (See N72-21121 12-07)
Avail NTIS HC $6 00/MF $0 95

It appears that the prediction of the Arctic ionosphere in the manner and with the accuracy accomplished for moderate latitudes is not yet possible However, from already established general patterns, it seems feasible to provide an hourly updated and fairly accurate description by real time processing of data from a few observing stations A number of suitable observing techniques are discussed Author

N72-21124# Imperial Coll. of Science and Technology, London (England). Physics Dept.
THE POLAR EXOSPHERIC PLASMA
J O Thomas and A D R Phelps *In* AGARD Radar Propagation in the Arctic Jan. 1972 11 p refs (See N72-21121 12-07)
Avail: NTIS HC $6 00/MF $0 95

The main features of the spatial distribution of plasma in the earth's polar exosphere deduced from satellite observations are described and related to recent measurements of incoming particles of magnetospheric origin, particularly in the low energy range (about 1000 eV) The topics include (1) the termination of the terrestrial plasmasphere, (2) the identification and location of a ring or torus of enhanced plasma density surrounding each pole stationary with respect to the sun, and under which the earth rotates, (3) the geomagnetic control of ionization, with the recognition of effects occurring at certain universal times associated with the geometry of the geomagnetic axis earth-sun line system; and (4) the polar wind Some of the main physical processes contributing to both static as well as dynamic features of the overall structure of the polar plasma distribution are introduced Author

N72-21125# Air Force Cambridge Research Labs., L. G. Hanson Field, Mass
A DISCUSSION OF ARCTIC IONOGRAMS
R A Wagner and C P Pike *In* AGARD Radar Propagation in the Arctic Jan. 1972 20 p refs (See N72-21121 12-07)
Avail NTIS HC $6 00/MF $0.95

Examples of Arctic ionogram sequences, recorded on the AFCRL flying ionospheric laboratory, are presented It is shown that (1) Ionogram sequences facilitate the interpretation of oblique incidence echoes from E and F layer heights (2) Parameters of the Arctic ionosphere can be mapped by using the auroral oval as an ordering system (3) Vertical and oblique incidence echoes appearing on ground station ionograms can be interpreted in terms of the station's position relative to the auroral oval The analysis of a three-hour flight with six latitudinal scans underneath an auror[illegible]d shows the close relationship between auroral-type spor[illegible] choes and discrete auroras The investigation of 43 lati[illegible] cans through the auroral oval during times of low mag[illegible]ctivity revealed the existence of a particle-produced E layer which is oval-aligned, is 2 to 6 deg wide in corrected geomagnetic latitude and occurs at all corrected geomagnetic times This layer produces the night E layer An ionogram analysis procedure which uses oblique incidence F layer echoes is demonstrated, and the feasibility is suggested of monitoring the latitude of the southern edge of the polar F layer irregularity zone by using this technique Author

N72-21126# Stanford Research Inst, Menlo Park, Calif.
POLAR PROPAGATION EFFECTS ON VHF-UHF RADARS
Walter G Chestnut *In* AGARD Radar Propagation in the Arctic Jan 1972 38 p refs (See N72-21121 12-07)
Avail NTIS HC $6 00/MF $0 95

The effects upon VHF-UHF radar which are considered are wave distortions caused by wave interaction with E and F region auroral ionization, including auroral backscatter (auroral clutter) and forward scatter that leads to amplitude and angle scintillation Recent results of pulse-radar-backscatter studies from aurora are reviewed and theories of irregularity production are considered Aurorally produced radar tracking and amplitude scintillation are discussed Some results from aurorally disturbed monopulse tracking of satellites are presented Author

N72-21127# National Research Council of Canada, Ottawa (Ontario). Astrophysics Branch.
OBSERVATIONS OF 48 MHz AURORAL RADAR PROPAGATION ON A NETWORK IN THE AURORAL ZONE
A. G. McNamara *In* AGARD Radar Propagations in the Arctic Jan. 1972 8 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

Four auroral radars are operated on a continuous basis at Ottawa, Thompson, Churchill, and Great Whale in Canada. The Ottawa radar is at 40 deg latitude and the other three are at approximately 57 deg. in the auroral zone. The high incidence of auroral activity at these locations permits both statistical and detailed single event studies of radio aurora morphology and scattering mechanisms. In spite of magnetic aspect control, strong auroral backscatter signals are detected at all azimuths with aspect angles of up to 25 deg from the magnetic perpendicular. These observations create difficulties in explaining radar aurora in terms of ion acoustic waves developed from linear models such as the two-stream instability theory. As well as direct auroral backscatter, the radars sometimes detect sporadic E propagated ground scatter, usually in association with auroral disturbance. the simultaneous observations of these auroral phenomena by the multiple stations permit more definitive measurements of the processes involved. Author

N72-21128# Max-Planck-Institut fuer Aeronomie, Lindau Uber Northeim (West Germany)
CURRENT EXPERIMENTAL RESULTS FROM A VHF-CW AURORAL BACKSCATTER NETWORK IN SCANDINAVIA
G. Lange-Hesse *In* AGARD Radar Propagation in the Arctic Jan 1972 16 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

VHF bistatic, continuous wave auroral backscatter communications (radio aurora) carried out since autumn 1967 on a network in Scandinavia and northern Germany were analyzed with respect to the influence of daytime, seasonal, and geomagnetic latitude on frequency occurrence Examples are presented which show the close control of the VHF auroral backscatter by the polar electrojet. Examples are given for the correlation between optical and radio aurora. Author

N72-21129# Stanford Research Inst., Menlo Park, Calif
AURORAL RADAR BACKSCATTER STUDIES FROM HOMER, ALASKA
W. G. Chestnut, J. C. Hodges, and R. L. Leadabrand *In* AGARD Radar Propagation in the Arctic Jan 1972 11 p refs Sponsored in part by DASA, NSF, and RADC (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

Radar aurora were studied using a backscatter radar at six frequencies from 50 MHz to 3000 MHz. It was found that the frequency dependence of the volume scattering cross section of the auroral echoes is nearly exponential with frequency. The slope of this frequency dependence was found to vary with time but averaged 33 db per 1000 MHz. The magnetic aspect sensitivity was found to be nearly independent of frequency. the scattering cross section decreased by about 10 db per degree of aspect angle. Auroral radar echoes at a frequency of 139 MHz were compared with the location of particle precipitation as measured during fourteen passes of the OV1-18 satellite. It is found that, except for periods of very active aurora, nighttime radar aurora was never collocated with peaks in proton energy flux. Where a radar aurora was located, measured particle precipitation fluxes were adequate to produce equilibrium E region electron densities greater than 70,000 el/cc. Thus E region electron densities necessary for radar auroras seem to be produced by precipitating particles. Author

N72-21130# Lincoln Lab., Mass Inst of Tech., Lexington
SOME PROPERTIES OF RADAR AURORAL ECHOES AS OBSERVED AT A FREQUENCY OF 1295 MHz
T. Hagfors *In* AGARD Radar Propagation in the Arctic Jan 1972 16 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

Observations are described of radar auroras made at a frequency of 1295 MHz from Millstone Hill, Massachusetts. From maps of power returned versus azimuth, elevation angle, and range of specific events of diffuse aurora, it was found that a mean height of auroral echoes is close to 110 km, that the half power thickness is 7 km, and that the power scattered drops 3 db when the aspect angle with respect to the magnetic field is increased from zero to 0.4 deg. Spectral analysis of echoes returned from a volume of 10 x 10 x 10 cu km with a resolution of 600 Hz reveals a great variety of spectra, many of which are narrow and displaced as if from an ion-acoustic density instability. Other spectra are wide and contain contributions from approaching and receding waves simultaneously. The wide spectra apparently are associated with regions where the radar beam is normal to the electrojet current. Simultaneous observations of auroral echoes and particle precipitation show that radio auroras may be observed without any measurable electron precipitation. Author

N72-21131*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
MICROSTRUCTURE OF RADIO AURORA SCATTERING REGIONS
A. Egeland (Oslo Univ., Norway), J. Holtet (Oslo Univ., Norway), and N. C. Maynard *In* AGARD Radar Propagation in the Arctic Jan. 1972 11 p refs (See N72-21121 12-07)
(NASA-TM-X-68302) Avail: NTIS CSCL 20N

Summaries are presented for studies of radio scattering from auroral ionization. Analyses were made of auroral returns from scaled, pencil beam radio systems. A brief discussion of scattering theories is given. Measurements of small scale fields, particle precipitation, and auroras are described. The microstructure and dynamics of auroras are also considered. Author

N72-21132# Western Ontario Univ., London Centre for Radio Science.
ION-ACOUSTIC WAVES IN AURORA
P. A. Forsyth and G. F. Lyon *In* AGARD Radar Propagation in the Arctic Jan. 1972 5 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

Evidence is presented that ion-acoustic waves exist in the auroral plasma and that these waves contribute to the scattering of radio waves at both VHF and UHF frequencies. Recent results suggest that this kind of clutter will be observed even at latitudes where the line-of-sight may not be perpendicular to the magnetic field lines. It is also suggested that ion-acoustic waves may contribute to the angular scintillations observed at high latitudes for transionospheric propagation paths using UHF radio waves. Author

N72-21133# Saskatchewan Univ., Saskatoon. Inst. of Atmospheric Studies.
POLARIZATION OF WAVES SCATTERED FROM AURORA
A. Kavadas *In* AGARD Radar Propagation in the Arctic Jan. 1972 13 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

Various interactions which lead to depolarization and cross-polarization are examined and correlated to particular types of aurora and properties of the scattering medium. Experimental results obtained from complete polarization measurements are used to demonstrate the nature of these interactions and the resulting changes in the polarization of the propagating wave. The experimental results were obtained with a time-sharing polarimeter which recorded six orthogonal components of aurorally backscattered waves at 42 MHz. Waves scattered in the forward direction were studied with partial polarization measurements (two orthogonal components) of radio star scintillations. The polarization of the received wave correlates with magnetic activity. Author

N72-21134# Royal Radar Establishment, Malvern (England).
NONSPECULAR IONOSPHERIC CLUTTER IN THE VHF AND UHF BANDS
G. N. Taylor *In* AGARD Radar Propagation in the Arctic Jan. 1972 9 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

The intensity of weak scattering from electron density irregularities in the high latitude ionosphere, in directions not perpendicular to the magnetic field is considered. Signals may cause clutter in sensitive radar systems at wavelengths between 10m and 0.1m. The literature is surveyed, to obtain typical and worst case values of the rms density deviation and scale size of the irregularities, and to select appropriate spatial autocorrelation functions. Assuming an isotropic distribution, scattering cross sections are calculated. It is concluded that nonspecular clutter is not likely to be more intense than the background incoherent (Thomson) scatter signals at wavelengths less than about 4m, unless the acf becomes markedly non-Gaussian. The spatial variability and spectral characteristics of incoherent and nonspecular clutter signals are discussed briefly. Author

N72-21135# Battelle Memorial Inst., Columbus, Ohio
A PROGRAM FOR THE INVESTIGATION AND SIMULATION OF AURORAL INSTABILITY MECHANISMS
J. T. Coleman *In* AGARD Radar Propagation in the Arctic Jan. 1972 11 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

A program is described for the simulation and analytical investigation of the scattering mechanisms of the radio aurora. The program is divided into two parts: the first is a simulation, on a scaled basis, of the important plasma mechanisms of the E region and its scattering conditions, and the second is a computation of the theoretical coherent interaction instability cross sections. Experimental evidence is presented for sensitivity of the coherent cross section to the drift current level, the local electron temperature, the local magnetic field intensity, gradients, and other parameters. The theoretical model estimates the differential radar cross section (in the hydrodynamic approximation) and includes the effects of relative drift between ions and electrons, and the gradient in electron density. In its present form, the model includes forward scatter, backscatter, and general bistatic scatter. The computation includes the frequency spectrum introduced by interaction with wave instabilities. Author

N72-21136# Raytheon Co., Sudbury, Mass.
PHASE COHERENT HF RADAR OBSERVATIONS OF BARIUM RELEASES IN THE ARCTIC IONOSPHERE
G. D. Thome *In* AGARD Radar Propagation in the Arctic Jan. 1972 6 p ref (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

Radar observations are reported which show that the development of optical striations is accompanied by an abrupt broadening of the Doppler spectrum, leading to returns with Doppler widths comparable to those observed from the natural radio aurora. In contrast to the natural ionosphere, the barium plasma is generated at a known instant of time and is confined to a limited volume of space. This makes it possible to study the evolution of irregularities in this plasma as a function of time and to study their radar aspect sensitivity without using narrow beam antennas. Prior to optical striation development, the barium cloud behaves as a smooth overdense target, exhibiting a discrete Doppler spectrum and producing regular Faraday fading. After the development of striations, the Doppler spectrum becomes diffuse and Faraday fading is lost. Author

N72-21137# Kiruna Geophysical Observatory (Sweden).
POLAR PROPAGATION EFFECTS ON RADIO-ASTRONOMICAL AND SATELLITE TRANSMISSIONS
Ludwik Liszka *In* AGARD Radar Propagation in the Arctic Jan 1972 8 p refs (See N72-21121 12-07)
Avail NTIS HC $6.00/MF $0.95

High latitude studies of scintillation phenomenon in radio signals from radio astronomy sources and satellites are reviewed. Morphology of high latitude scintillation is discussed, including geographic distribution, diurnal variations, and relation to magnetic activity. Studies of statistical properties of the signal received on the ground were found to be a useful source of information about the nature of irregularities in the ionosphere. Studies are reviewed with emphasis on parameters of the scintillation-producing layer. Finally, results of height determinations using the space receiver method and satellite transmissions are briefly discussed. Author

N72-21138# Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.
SATELLITE SCINTILLATIONS IN THE HIGH LATITUDE F-LAYER IRREGULARITY REGION
Jules Aarons *In* AGARD Radar Propagation in the Arctic Jan. 1972 8 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

Polar observations from Spitzbergen show a trough or decrease in scintillation index, on the night side between an oval and a polar region. Using radio star data at 113 and 228 MHz, scintillation index increases of 0.50 to 7 were noted with increases in K index (propagation path intersection through the F layer (350 km) at 67 deg). Recordings of 136 MHz satellite signals from Narssarssuaq, Greenland also show that mean scintillation index increases during magnetic storms within the irregularity region. Thule observations of 40 MHz transmissions indicate the overhead pattern at invariant latitudes near 86 deg. A model is presented of a core of high electron density irregularities, probably centered above the auroral oval, but with a high occurrence of irregularities over the polar cap. In addition, the irregularity region at lower intensity extends below the oval at night. Author

N72-21139# Western Ontario Univ., London. Centre for Radio Science.
ANGULAR DEVIATION OF RADIO WAVES
G. F. Lyon and P. A. Forsyth *In* AGARD Radar Propagation in the Arctic Jan. 1972 5 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

Angular deviations due to typical departures from horizontal stratification are modelled. In particular, the steep gradients and troughs in electron density typical of the polar ionosphere are considered. The results suggest that systems which depend upon precise measurements of angle of arrival for radio waves in the frequency range at least to the upper end of the VHF range may be subject to significant unavoidable error. Author

N72-21140# Norwegian Defence Research Establishment, Kjeller.
HIGH LATITUDE SATELLITE SCINTILLATION
J. Frihagen and O. Bratteng (Auroral Obs., Tromsoe, Norway) *In* AGARD Radar Propagation in the Arctic Jan. 1972 8 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

Numerous measurements of the height of ionospheric irregularities giving rise to satellite scintillation have shown them to be located in the region 300-600 km above the ground. Observations show that there is no appreciable reduction in scintillation at 136 MHz when a satellite loses height from in excess of 1000 km to less than 300 km. When observed from Tromso (70 deg N) the mean scintillation depth at 136 MHz increases from south to north, increases with K, shows nighttime maxima and daytime minima. Some results of electron density from rockets launched from Andenes (69 deg N, 16 deg E) show strong irregularities, the electron density varying by up to 25% over a few tens of meters north of auroral forms. Over the auroral forms, the electron density varies smoothly. Author

N72-21141# Max-Planck-Institut fuer Aeronomie, Lindau Uber Northeim (West Germany)
SATELLITE SCINTILLATION BETWEEN 43 DEG AND 65 DEG NORTHERN LATITUDE FROM 1964 TO 1969

Gerd K. Hartmann *In* AGARD Radar Propagation in the Arctic Jan. 1972 12 p refs (See N72-21121 12-07)
Avail: NTIS HC $6.00/MF $0.95

Since November 1964 till May 1969 the radio signals from the beacon satellite Explorer 22 were continuously recorded at Lindau, for obtaining the ionospheric electron content from Faraday-effect- and dispersive-Doppler-effect measurements. The obtained amplitude and phase recordings were compared. When the root mean square phase deviation, during distortions, e.g. phase scintillation, was equal or greater 1 radian, fast amplitude scintillations that exceeded 6 dB amplitude variations were found. The narrow scintillation belt, which was observed between 50 deg and 60 deg northern geographic latitude consists of two independent sub-belts. It is suggested that the scintillation activity increases by a factor of 2 for weak scintillations and by a factor of 4 strong scintillations, when Kp exceeds 3c. A southward motion with increasing magnetic activity was observed. In summer the SOFM seems to be approximately 2 deg further north than in winter. Author

N72-21142# Max-Planck-Institut fuer Aeronomie, Lindau Uber Northeim (West Germany).

POLAR PROPAGATION EFFECTS ON HF RADARS

H. G. Moeller *In* AGARD Radar Propagation in the Arctic Jan. 1972 15 p refs (See N72-21121 12-07)
Avail NTIS HC $6.00/MF $0.95

The CW and pulse transmission experiments in the auroral and subauroral region are reviewed. The phenomena that affect propagation are dispersion of F2 critical frequency and hence horizontal electron density gradients, field-aligned irregularities in the F2 and E region, auroral Es, and D region absorption. The variation of these phenomena in time and space and the correlation with magnetic activity are discussed. Following propagation, effects were observed due to these phenomena: Transmission paths transversing horizontal gradients of electron density become asymmetric which has to be taken into account in MUF calculations. Strong curtains of irregularities cause non-great-circle transmission. The NGR transmission may be advantageous if it results in a MUF enhancement, or in bypassing an area of enhanced absorption, it is disadvantageous as time delay of the received signals is increased. The enhancement is often observed by auroral Es. Author

N72-21143# Stanford Research Inst., Menlo Park, Calif.

FREQUENCY DISTORTION IN AURORAL HF PROPAGATION

J. S. Lomax *In* AGARD Radar Propagation in the Arctic Jan. 1972 12 p refs (See N72-21121 12-07)
Avail. NTIS HC $6.00/MF $0.95

The HF propagation in auroral regions results in greater frequency distortion of signals than that encountered at mid-latitudes. Observational data on the characteristics of this distortion as taken on a transauroral path between Palo Alto, California and Thule, Greenland are presented. Details of the frequency distortion are given in terms of measured power spectral densities, Doppler shifts, and the corresponding phase fluctuations. These quantities are in turn related to the temporal correlation function of the channel. Author

N72-21144# Rome Air Development Center, Griffiss AFB, N.Y.

HIGH ALTITUDE HS SIGNAL TRANSMISSION CHARACTERISTICS

R. A. Mather, B. L. Holtzclaw (GE Co., Syracuse, N. Y.), and R. W. Swanson (GE Co., Syracuse, N. Y.) *In* AGARD Radar Propagation in the Arctic Jan. 1972 22 p refs (See N72 21121 12 07)
(Contract F30602-69-C-0217)
Avail. NTIS HC $6.00/MF $0.95

Measurements made on HF sky wave signals propagated over two high-latitude 2000 nmi paths terminating at a receiving site in central New York State are presented. Signal characteristics include propagation loss, spectral spreading, and temporal spreading as a function of signal bandwidth (either 7.7 kHz or 100 kHz). The transmitting sites were located at Thule, Greenland and Keflavik, Iceland so that HF propagation information could be collected on a path that was both in the polar cap region and in midlatitude, and on one that passes along and through the outer edge of the auroral oval. Oblique soundings were conducted over each path so that the model(s) of propagation for the signal(s) measured could be determined. Analyses of the results obtained indicated that the spectral and temporal spreading are a very strong function of the mode of propagation, especially for signals transmitted over the Thule path. The data are depicted as a function of time of day to illustrate the diurnal variation of the parameters considered. Author

N72-21145# Radio and Space Research Station, Slough (England).

POLARIZATION EFFECTS ON SKY-WAVE PATHS AT HIGH LATITUDES

P. A. Bradley *In* AGARD Radar Propagation in the Arctic Jan 1972 9 p refs (See N72-21121 12-07)
Avail. NTIS HC $6.00/MF $0.95

The principles involved in the determination of polarization coupling losses on sky-wave paths are briefly discussed. The way these losses depend on the limiting polarizations of the upgoing and downcoming waves at the bottom of the ionosphere are illustrated, and it is shown that at frequencies in excess of about 2 MHz simple expressions are available for these limiting polarizations which are independent of the form of the ionization profiles. Limiting polarizations and polarization coupling losses are functions of wave frequency and of ray-path directions with respect to the direction of the earth's magnetic field. At high latitudes, changes in the angle between the field and ray path directions lead to marked variations in polarization coupling losses for nearby paths. Sample calculations are presented for a range of conditions to illustrate single- and two-way path losses. The calculations include the case of two-hop paths where there are additional features associated with the change of polarization at ground reflection. The results show the importance of the optimum choice of aerial polarization. The way in which backscatter amplitude return patterns can be influenced by polarization effects is also illustrated. Author

N72-21146# Air Force Cambridge Research Labs., L. G. Hanson Field, Mass.

SPATIAL CORRELATION OF AURORAL RADIO ABSORPTION

K. Toman, R. J. Cormier, and J. J. Corbett *In* AGARD Radar Propagation in the Arctic Jan. 1972 9 p refs (See N72-21121 12-07)
(Contract F19628-70-C-0237)
Avail. NTIS HC $6.00/MF $0.95

The temporal behavior of auroral radio absorption was measured with riometers at medium and high latitude displays complex patterns which differ spatially. These differences may be limited to a time displacement of otherwise similar absorption patterns indicating a movement which could be interpreted in terms of a structured, locally enhanced, precipitating, energetic particle stream that moves over a geographic area. In order to assess numerically the spatial coherence of auroral radio absorption, a correlation study was undertaken of absorption patterns as recorded by more than eight riometer stations during five days of varying activity containing the magnetic storm of 18 April 1965. Using a day as the sample size, the results of this study provide a view of the spatial coherence of auroral absorption. Author

N72-21147# Alaska Univ., College. Geophysical Inst.

SWEEP FREQUENCY BACKSCATTER RADARS AS DETECTORS OF HIGH LATITUDE IONOSPHERIC PHENOMENA

Howard F. Bates *In* AGARD Radar Propagation in the Arctic Jan. 1972 9p refs (See N72-21121 12-07)
Avail NTIS HC $6.00/MF $0.95

Characteristics of irregularities causing high frequency scatter and propagation problems are examined, along with auroras producing these large and small scale irregularities. Auroral and nonauroral echoes were identified through high latitude, high frequency backscatter. Nonauroral echoes consist of F layer ground scatter, nonauroral sporadic E including E ground scatter, meteor echoes, and oblique spread F echoes. Auroral echoes were found to be caused by backscatter from both the E and F layers. J.A.M.

N72-21148# Technical Univ. of Denmark, Lyngby.
ON THE POLAR SLANT E CONDITION, ITS IDENTIFICATION, MORPHOLOGY AND RELATIONSHIP TO OTHER ELECTROJET PHENOMENA
Jens K. Olesen *In* AGARD Radar Propagation in the Arctic Jan. 1972 19 p refs (See N72-21121 12-07)
Avail. NTIS HC $6.00/MF $0.95

Ionograms and morphological statistics of polar slant E condition are discussed, emphasizing two stream or plasma ion wave instability. Observation sites and data periods for ionosonde and fixed frequency scatter measurements are also listed. J.A.M.

N72-21149# Paris Univ. (France).
HIGH FREQUENCY BACKSCATTER OBSERVATIONS AT MEDIUM LATITUDES OF HIGH LATITUDE FIELD ALIGNED IRREGULARITIES
M. Crochet, D. Barreau, and J. C. deMaistre *In* AGARD Radar Propagation in the Arctic Jan. 1972 9 p refs In FRENCH; ENGLISH summary (See N72-21121 12-07)
Avail. NTIS HC $6.00/MF $0.95

Abnormal echoes ascribable to the presence of field aligned high latitude irregularities in the F layer were frequently observed from the Valensole station (44 deg N, 6 deg E), by means of decametric wave backscatter radar. A comparison of characteristic recordings with data collected simultaneously at the Lindau station (51 deg N, 10 deg E) where such echoes are regularly obtained reveals the influence of the station latitude on the observation of such phenomena. Author

N72-21150# Air Force Cambridge Research Labs., L. G. Hanson Field, Mass.
HF AURORAL BACKSCATTER AND THE SCINTILLATION BOUNDARY
Jules Aarons *In* AGARD Radar Propagation in the Arctic Jan. 1972 11 p refs (See N72-21121 12-07)
Avail. NTIS HC $6.00/MF $0.95

A 19 MHz backscatter unit was operated, and a series of measurements of radio star scintillations (30 to 228 MHz) and satellite beacon recordings (20 to 136 MHz) were made. A 50 MHz radar was added to the observing program. In a recent analysis of the dual frequency field aligned backscatter, a separation into E and F-layer returns was made. It was found that VHF auroral returns (from E-layer heights) were accompanied 49% of the time by HF returns. The two factors suggested to be responsible for the absence of a 1 1 correlation were probably absorption at HF and variations in antenna launch angle for the two systems. The HF auroral backscatter (E and F-layer heights) was accompanied only 11% of the time by VHF backscatter. During the 17 months of observation at low solar activity, the percentage of occurrence of 19 MHz field aligned scatter was 2%; of 50 MHz auroral scatter 0.5%. Author

N72-21151# Avco Corp., Wilmington, Mass.
FM/CW HF BACKSCATTER OBSERVATIONS OF RADIO AURORA
A. H. Katz *In* AGARD Radar Propagation in the Arctic Jan. 1972 8 p refs (See N72-21121 12-07)
(Contract F30602-70-C-0086)
Avail. NTIS HC $6.00/MF $0.95

Observations of HF backscatter from radio aurora using an FM/CW radar located at field sites near Rome, N. Y. (43.2 deg N, 75.5 deg W) are discussed. Both wideband (at 6.5-30 MHz, 3 kW average power) and narrowband (fixed frequency soundings at 20 kW average power) backscatter measurements were made. The wideband soundings determine the modes of propagation, frequency extents, and time delays of the backscattered energy. The high resolution narrowband soundings indicate the movements that occur in the radio auroral regions. Examples of these motions are presented, showing events that last for 5 minutes, exhibiting range changes which imply apparent velocities near or above the speed of sound at F-region heights. The wideband backscatter measurements were processed in a form which allows the absolute signal level of the backscattered energy to be determined. Author

N72-21152# General Electric Co., Syracuse, N.Y.
IONOSPHERIC REFRACTION EFFECT ON THE GEOMETRY OF FIELD-ALIGNED IONIZATION
George H. Millman *In* AGARD Radar Propagation in the Arctic Jan. 1972 15 p refs (See N72-21121 12-07)
Avail. NTIS HC $6.00/MF $0.95

A method is presented which utilizes the concept of the ionospheric refraction phenomenon in the calculation of the magnetic field-propagation aspect angle. The effect of ionospheric refraction at frequencies in the HF-UHF band is evaluated for one location in the Northern Hemisphere. Author

N72-21153# Institute for Telecommunication Sciences, Boulder, Colo.
A MODEL FOR THE STUDY AND PREDICTION OF AURORAL EFFECTS ON HF RADAR
Vaughn Agy *In* AGARD Radar Propagation in the Arctic Jan. 1972 10 p refs (See N72-21121 12-07)
Avail. NTIS HC $6.00/MF $0.95

A description is given of an ionospheric propagation model and its application to high latitude HF radar propagation. Computer simulation of the model makes possible the rapid determination of the area of (1-hop) coverage, and computation of auroral absorption and geometrical features of auroral clutter. The results are presented in a map on which are shown appropriate parameter contours. Operating frequency, station location, time, month, sunspot number, and clutter height are all arbitrary. The explicit approximations specifying the model can be changed within the basic framework of the computer program to bring about better agreement with observations. Author

N72-22136# Advisory Group for Aerospace Research and Development, Paris (France).
TECHNICAL EVALUATION REPORT ON AGARD SPECIALISTS MEETING ON RADAR
J. Frihagen (Norwegian Defense Res. Estab., Kjeller) Jan. 1972 21 p refs Conf. held at Lindau/Harz, West Germany, 13-17 Sep. 1971
(AGARD-AR-33) Avail: NTIS

A conference on radar propagation in the Arctic is presented, including sessions on polar morphology, VHF-UHF propagation backscatter, polar scintillation, VHF propagation transmission, and HF propagation backscatter. Summaries, recommendations, and future studies are considered for radio aurora, radar aurora, VHF-UHF incoherent scatter, scintillation, and satellite beacon studies. Backscatter observations and HF scatter and communications are also reviewed. J.A.M.

N73-10187# Advisory Group for Aerospace Research and Development, Paris (France).
AEROSPACE TELECOMMUNICATIONS SYSTEMS
Aug. 1972 356 p refs Partly in ENGLISH and partly in FRENCH Proc. of the 23d Tech. Meeting of the Avionics Panel of AGARD, London, 15-18 May 1972
(AGARD-CP-103) Avail. NTIS HC $19.75

Expanded telecommunication system requirements can be

met by data compression methods and digital imaging schemes, efficient bandwidth utilization and adaptation techniques, tactical environment ground terminal measurements for satellite communications, and digital/analog communications for automatic message systems and interference suppression. For individual titles, see N73-10188 through N73-10213.

N73-10188 Royal Aircraft Establishment, Farnborough (England). Radio Dept.

TECHNICAL EVALUATION REPORT ON 23D AVIONICS PANEL TECHNICAL MEETING ON AEROSPACE TELECOMMUNICATIONS SYSTEMS, 15-18 MAY 1972

P. G. Whicher *In* AGARD Aerospace Telecommun. Systems Aug 1972 9 p (For availability see N73-10187 01-07)

Activities in telecommunications research and development, and in network planning monitoring, and utilization are reported. An important conclusion formed states that digital techniques offer real prospects of supplanting traditional analog methods in a wide range of future applications in aerospace systems. Emphasis is placed on growing problems of electromagnetic compatibility, interference, and jamming and the difficulties of accomodating multiple satellite systems in synchronous orbit. G.G.

N73-10189 Laboratoire Central de Recherches Thomson-CSF, Orsay (France). Div. Materiels Avioniques et Spatiaux.

REDUCTION OF APPLIED REDUNDANCY IN THE TRANSMISSION OF IMAGES [REDUCTION DE LA REDONDANCE APPLIQUEE A LA TRANSMISSION DES IMAGES]

T. A. Hawkes and P. A. Simonpieri *In* AGARD Aerospace Telecommun. Systems Aug 1972 14 p refs In FRENCH (For availability see N73-10187 01-07)

A procedure relevant to the simple reduction of applied redundancy in image transmission is presented. The algorithm treatment and known reception permits the reconstruction of signals without transmitting the information over the length of the pattern interval. After an evaluation of all possible procedures, the effect of first simulation elements on the ordinates of the proposed algorithm with image restoration imprints is examined. Essential parameters, functions of the system, and the results obtained are given. Transl. by E.H.W.

N73-10190 Perkin-Elmer Corp., Norwalk, Conn.

DIFFERENTIAL PULSE CODE MODULATION TRANSMISSION OF SAMPLED AERIAL IMAGERY

R. J. Arguello, H. R. Sellner, and J. A. Stuller *In* AGARD Aerospace Telecommun. Systems Aug 1972 20 p refs (For availability see N73-10187 01-07)

An analysis, simulation and discussion of the effects of quantizer noise and communication errors on differential pulse code modulation (DPCM) transmission of sampled aerial imagery are reported. Simulations are presented that describe: (1) DPCM transmission of photographic scenes which have been scanned and sampled at the Nyquist rate, and (2) the effects of inserting periodic PCM updates in order to correct DPCM communication errors. Two, three and four bit DPCM transmission systems are discussed. Author

N73-10191 Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass.

COMPUTER AIDED EVALUATION OF RECONNAISSANCE IMAGE COMPRESSION SCHEMES USING AN ON-LINE INTERACTIVE FACILITY

J. C. Mott-Smith, F. H. Cook, and J. M. Knight (Mitre Corp., Bedford, Mass.) *In* AGARD Aerospace Telecommun. Systems Aug 1972 20 p refs (For availability see N73-10187 01-07) (Contract F19628-71-C-0002)

A method is proposed of evaluating compression algorithms applied to pictures and applied to several well-known techniques, most of which already have one or more hardware implementations. General conclusions are that delta modulation and differential pulse code modulation which use three or fewer bits per picture element are detrimental, and that the zero- and first-order predictors may give some compression but certainly less than a factor of two on the average. The defects in the algorithms which limit their usefulness on pictorial data is identified with their poor correlation from one line of the picture to the next. The importance of proper data management for pictorial communication is illustrated, and by implication, shown to be much more important than the data compression algorithms. Relevant to the data management proposals, some methods of improving the cosmetic quality of sparsely sampled images are shown. Author

N73-10192 Rensselaer Polytechnic Inst., Troy, N.Y. Systems Engineering Div.

A TUTORIAL ON DIGITAL TECHNOLOGY WITH EMPHASIS ON DIGITAL COMMUNICATIONS AND FILTERING

Lester A. Gerhardt *In* AGARD Aerospace Telecommun. Systems Aug. 1972 7 p refs (For availability see N73-10187 01-07) (Contracts AF 49(638)-1627; DAAB07-69-C-0365)

The major advantages of a digital approach to communications are considered and digital technology and its effect on communications are outlined. Under the umbrella of a generalized model of a digital communications system, the status of the theory is reviewed and practical implementations are given. The relationship between theory and practice is emphasized using digital filtering as typical of the achievements in this area. Author

N73-10193 Politecnico di Torino (Italy). Is. di Elettronica e Telecomunicazioni.

ON THE EFFICIENT BANDWIDTH UTILIZATION IN DIGITAL TRANSMISSION

S. Benedetto, V. Castellani, C. Cianci (Centro Studi e Laboratori Telecomunicazioni), and U. Mazzei (Studi e Laboratori Telecomunicazioni) *In* AGARD Aerospace Telecommun. Systems Aug 1972 13 p refs (For availability see N73-10187 01-07)

The problem of the efficient bandwidth utilization of a digital transmission channel is investigated by working out a complete example with a rather realistic channel model. The bandwidth efficiency in digital transmission is contrasted by the channel distortion impairments. A useful shaping of the signal spectrum and the use of a transversal equalizer are analyzed. Multilevel SSB amplitude modulated signals are assumed. System performances are discussed and evaluated using two different criteria: the peak distortion of the received signal and the average error probability of the received sequence. A general description of the different parts of the system is first given and a detailed discussion of the evaluation procedures is presented. Results are given for PAM and partial response coded (PRC) signalling schemes. System evaluation is finally discussed in terms of bandwidth efficiency. Author

N73-10194 Service Technique des Telecommunications de l'Air, Paris (France).

UTILIZATION AND SUPPLENESS OF HIGH NUMERICAL DISCHARGE SUPPORT IN TELECOMMUNICATIONS [UTILISATION ET SOUPLESSE D'UN SUPPORT NUMERIQUE A DEBIT ELEVE DANS UN SYSTEME DE TELECOMMUNICATIONS]

G. Bomont (Service Tech. de la Navigation Aerienne), P. P[illegible]t, and G. David *In* AGARD Aerospace Telecommun. Sy[illegible]ms Aug 1972 12 p refs In FRENCH (For availability see N73-10187 01-07)

The use of numerical control to compress syllabic delta modulated voice signals in air navigation telecommunication systems is discussed. The principles of the multiplexing numerical system and the transmission methods utilized are given. An organizational air navigation control system is illustrated. Transl. by E.H.W.

N73-10195 Texas Instruments, Inc., Dallas.

SYNTHESIS AND EVALUATION OF AN OPTIMUM SAMPLED DATA FM DEMODULATOR

Alan L. McBride *In* AGARD Aerospace Telecommun. Systems Aug 1972 11 p refs (For availability see N73-10187 01-07) (Contract F30602-70-C-0180)

A digitalized or sampled-data FM demodulator recursive algorithm is synthesized and its signal-to-noise ratio performance evaluated. A recursive estimator is derived that optimally estimates the message of a noisy sampled FM process. The incoming analog noisy FM process is in-phase and quadrature sampled to reduce the bandpass RF waveform to a sampled baseband process

The modulating process is modeled as a discrete linear filter by state variable techniques. The maximum a posteriori (MAP) criterion is used to develop a recursive cost function. Minimization techniques used in optimal control theory are employed to derive the two-point boundary-value (TPBV) problem from this cost-function. Discrete invariant imbedding is then used to solve the TPBV problem and obtain the recursive solution algorithm. A single-pole message filter example is reviewed. Discussed in this example are performance curves obtained by simulation of the inverse output mean-square error versus input carrier-to-noise ratio. The demodulator is shown to exhibit FM threshold extension capability. Author

N73-10196 Philco-Ford Corp., Palo Alto, Calif.
DIGITAL EQUIVALENT PSK RECEIVER TECHNIQUES
Francis D. Natali *In* AGARD Aerospace Telecommun. Systems Aug. 1972 13 p refs (For availability see N73-10187 01-07)
(Contract F30602-69-C-0099)

All-digital techniques for receiving and coherently detecting moderate data rate (less than 1 Mbps) PSK signals in real time are discussed. A receiver employing synchronous bandpass sampling and A/D conversion of the IF signal is described. Sampler synchronization, bit synchronization, and data detection are performed by a special-purpose digital processor. Analytical methods are developed for predicting receiver performance, and experimental data is presented to indicate the degree of agreement that one might expect. Author

N73-10197 Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany).
ADAPTIVE PRE-WHITENING FILTER
R. Klemm *In* AGARD Aerospace Telecommun. Systems Aug. 1972 7 p refs (For availability see N73-10187 01-07)

Some methods are shown for calculating the optimal linear pre-whitening filter function from real time computed correlation functions. The problem is due to the optimal detection of target signals in correlated noise in radar technique. In principle the received data are multiplied with the inverse of the correlation matrix of the noise, based on the Wiener theory, however, a linear function, that is, the first column of the inverse of the correlation matrix can also be given. Three methods are shown and discussed, by means of which it is possible to calculate the first column in real time without inverting the whole matrix. Author

N73-10198 Mitre Corp., Bedford, Mass.
A FLEXIBLE HARDWIRED FAST FOURIER TRANSFORM DIGITAL PROCESSOR
E. A. Palo and G. C. O'Leary *In* AGARD Aerospace Telecommun. Systems Aug. 1972 15 p refs (For availability see N73-10187 01-07)
(Contract F19628-71-C-0002)

A hardwired digital processor based on the Cooley-Tukey algorithm is presented. A laboratory prototype has been built with two modes of operation. As a cascade fast Fourier transformer, it can simultaneously calculate transforms of two independent, continuous data streams at word rates in excess of 3 MHz. As a nonrecursive digital filter, it can produce filter impulse responses of up to 32 points. The digital filter also operates from data sources with word rates exceeding 3 MHz. The processor has been integrated into a system with other signal processing components including a small general purpose computer. Laboratory demonstration of the processing system as a spectrum analyzer and as an adaptive filter for distortion correction is discussed. Author

N73-10199 Siemens A.G., Munich (West Germany).
THE ADAPTIVE EQUALIZATION OF TRANSMISSION SYSTEMS
K. H. Moehrmann *In* AGARD Aerospace Telecommun. Systems Aug. 1972 16 p refs (For availability see N73-10187 01-07)

After a general introduction some of the principles of adaptive optimization are explained using as example the automatic identification of the transfer function of a linear system under operating conditions. Then several techniques for the automatic minimization of the linear distortions in communication channels are discussed with emphasis on telephone channels for fast transmission of digital data. Some filter structures suited for this purpose are described together with several possible strategies to implement the settings of the variable filter elements automatically during a training period before information transmission or in an adaptive manner during transmission. Finally, after discussing the partial-response technique and the equalization of digital data signals transmitted at high bit rates over long-haul coaxial carrier systems, some related applications of adaptive techniques are described concerning the equalization of long cable systems used for analog transmission of television signals, the equalization of FM/FDM radio relay systems due to elimination of intermodulation distortion and the adaptive cancellation of echoes in long distance telephone circuits. Author

N73-10200 Rensselaer Polytechnic Inst., Troy, N.Y. Systems Engineering Div.
ADAPTIVE EQUALIZATION WITHOUT TEST TRANSMISSIONS
Chia-Chi Chen and Lester A. Gerhardt *In* AGARD Aerospace Telecommun. Systems Aug. 1972 14 p refs (For availability see N73-10187 01-07)
(Contracts DAAB07-69-C-0365; AF 49(638)-1627)

An extended gradient method for iteratively solving sets of linear equations has been developed and used here as the algorithm to perform adaptive equalization. Although stress has been placed on using this algorithm without test transmissions, for transversal equalizers, the algorithm may also be used with test transmissions as well as for recursive equalizers. Initially, stationary, binary, bipolar channels are equalized without test signals. For highly dispersive channels, the algorithm uses a variable history of past sequences to provide more effective equalization. The algorithm, if used when test signals are available, permits channels to be equalized with multilevel signals transmitted instead of confining transmission to the binary, bipolar case. The algorithm has also been proven useful for adapting as equalizer in conjunction with a time varying channel because it can accomodate to rapidly varying characteristics. Author

N73-10201 North Atlantic Treaty Organization, Bruxelles (Belgium).
PROPAGATION CRITERIA WITH TACTICAL SATELLITE COMMUNICATIONS
H. J. Albrecht, M. Eggestad, and L. A. Maynard *In* AGARD Aerospace Telecommun. Systems Aug. 1972 13 p refs (For availability see N73-10187 01-07)

Tactical satellite communications may use a variety of frequency bands depending upon the application. Considering mobility and simplicity of equipment some of the more important aspects, the UHF range was found to be particularly suitable. In other words, operating frequencies are within the 200 to 400 MHz portion of the spectrum. Propagation criteria considered are: (1) scintillation effects due to ionospheric irregularities, (2) ray deviation caused by atmospheric layers, (3) multipath effects, and (4) transparency of surrounding materials. Scintillations are analyzed on the basis of experimental and theoretical results obtained. The subject of ray deviation is closely related to abnormal tropospheric conditions. With regard to multipath effects, the general aspects of ground reflections are analyzed for the purpose of evaluating their importance with mobile surface terminals. The problem of penetrating surrounding materials may be essential, whenever a porous obstacle, such as vegetation, is present in the path between surface terminal and satellite. Author

N73-10202 North Atlantic Treaty Organization, Bruxelles (Belgium).
SYSTEM CONSIDERATIONS IN TACTICAL SATELLITE COMMUNICATIONS
H. J. Albrecht, R. Makaruschka, and R. Menzel *In* AGARD Aerospace Telecommun. Systems Aug. 1972 15 p refs (For availability see N73-10187 01-07)

The use of wide band satellites with frequency conversion and hard limiting displays certain disadvantages and limitations, particularly if the bandwidth is restricted to, e.g., 500 kHz in

the UHF range This causes the number of links to be limited if simultaneous operation is envisaged Another possible system uses wide band satellites with adjustable characteristics, such as linear, quasi-linear, or hard limiter operation. Considering wide bandwidths of the order of 10 MHz in the UHF range, some advantages may be gained by such adjustable characteristics under jamming conditions The vulnerability of the entire system can be reduced by single channel operation, employing satellites with separate channels covering the entire bandwidth of 10 MHz with multiple base band operation. Among the feasible combined systems are those using UHF and SHF For tactical satellite systems, a possible configuration comprises a quantity of smaller terminals operating on UHF with a satellite receiving on UHF and retransmitting on SHF to a powerful master surface terminal, acting as net control and relaying the retransmitted signal on SHF to the satellite, which again establishes a UHF link to the desired smaller terminal Author

N73-10203 Shape Air Defense Technical Center, The Hague (Netherlands)
GROUND TERMINAL MEASUREMENT REQUIREMENTS WITH RESPECT TO SATELLITE COMMUNICATIONS LINK AVAILABILITY
A N Ince and A Wallrabe *In* AGARD Aerospace Telecommun Systems Aug 1972 12 p refs (For availability see N73-10187 01-07)

Communications satellite systems are considered with multiple ground terminals carrying many voice channels, linked to each other via a geostationary satellite To obtain the required link capacities with specified performance it is necessary to set the levels of the assessing carriers very carefully to achieve the appropriate sharing of the satellite output power The satellite system control center measures link parameters and instructs the ground terminals to adjust transmitter powers in order to counteract the performance degradation due to external factors. The accuracy with which the system parameters can be measured determines how well the carrier levels may be controlled and consequently the availability of the communication links Measurement methods for some of the most important quantities are given and the accuracy achieved with an experimental satellite terminal is discussed Author

N73-10204 Admiralty Surface Weapons Establishment, Portsmouth (England)
SCOT SATELLITE COMMUNICATION TERMINAL
P R Lees *In* AGARD Aerospace Telecommun Systems Aug 1972 4 p (For availability see N73-10187 01-07)

SCOT is the satellite communication terminal in production for the Royal Navy for installation in frigates and certain other classes of ships It provides broadcast and ship-shore facilities within the SKYNET system A brief description of the terminal and some of the problems of access and control related to the necessity to fully exploit the terminal's capability are reported Author

N73-10205* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FACTORS AFFECTING FREQUENCY AND ORBIT UTILIZATION BY HIGH POWER TRANSMISSION SATELLITE SYSTEMS
Perry W Kuhns, Edward Miller, and Thomas A Malley *In* AGARD Aerospace Telecommun Systems Aug 1972 16 p refs (For availability see N73-10187 01-07)

The factors affecting the sharing of the geostationary orbit by high power (primary television) satellite systems having the same or adjacent coverage areas and by satellites occupying the same orbit segment are examined and examples using the results of computer computations are given The factors considered include required protection ratio, receiver antenna patterns, relative transmitter power, transmitter antenna patterns, satellite grouping, and coverage pattern overlap The results presented indicate the limits of system characteristics and orbit deployment which can result from mixing systems Author

N73-10206 Royal Air Force, Marlow (England)
AUTOMATIC MESSAGE SWITCHING AND DATA TRAFFIC HANDLING IN A MILITARY COMMUNICATIONS NETWORK
C H Blanchard *In* AGARD Aerospace Telecommun Systems Aug 1972 12 p refs (For availability see N73-10187 01-07)

Computer based message switching systems fulfill a necessary function within a military system, and it is expected that the size and complexity of these highly sophisticated systems will increase Some of the problems associated with the design, procurement and maintenance of such systems are Basic fact finding exercises, operational requirement, drafting of a procurement specification, and project definition and tender evaluation Author

N73-10207 Honeywell Information Systems, Inc , Tampa, Fla
THE AUTOMATED TECHNICAL CONTROL (ATEC) SYSTEM
Louis Calden and Anthony S Szalkowski (RADC N Y) *In* AGARD Aerospace Telecommun Systems Aug 1972 18 p refs (For availability see N73-10187 01-07)

The ATEC system assigns functions to men and machines so that each does most that which they do best In general, this means machine tasks include the collection, processing, sorting and retrieving of data under the direction of the man whose function includes reasoning, deciding, interpreting, controlling and directing The overall ATEC design philosophy provides bidirectional modularity for customization to the communication station and graceful degradation in case of failure Therefore, the total system capability is never lost by failures of even considerable portions of the ATEC The concept, structure and application of the ATEC system and its subelements are described Author

N73-10208 Air Force Communications Service, Richards-Gebaur AFB Mo
THE TRANSMISSION PERFORMANCE OF THE DEFENSE COMMUNICATIONS SYSTEM
Yuen-sun Fu and Robert L Ffik *In* AGARD Aerospace Telecommun Systems Aug 1972 9 p refs (For availability see N73-10187 01-07)

A system wide measurement program on the defense communications system was initiated in 1967 The sample plan and measurement procedures are discussed briefly A summary of the analysis results is presented It contains estimates of population means for frequency response, delay distortion impulse noise, idle channel noise and harmonic distortion for the voice channels within the defense communications system Finally, the 90 percent confidence interval as well as estimates of standard deviation are computed Author

N73-10209 Electronic Systems Div , L G Hanscom Field, Mass
DIGITAL VERSUS ANALOG COMMUNICATIONS SYSTEMS TECHNICAL AND ECONOMIC CONSIDERATIONS
Carl A Segerstrom *In* AGARD Aerospace Telecommun Systems Aug 1972 10 p (For availability see N73-10187 01-07)

The limitations of the current world wide analog transmission plant is viewed in terms of its data and voice handling capability In addition, improved data transmission is highlighted using microwave, cable or tropo when using digital rather than analog techniques in optimizing information flow Some of the system improvements expected in using digital switching techniques and the increased possibilities for the inclusion of technical control in the switch designs are discussed from a system viewpoint Since the current plant represents a large investment and outright replacement of an entire network is impractical, the process of hybridization and eventual all digital implementation over a 20 30 year interval is examined Finally some of the possible overall improved system characteristics are listed that cannot now be achieved in the present analog configuration Author

N73-10210 Lear Siegler Inc Grand Rapids Mich Instrument Div
KALMAN FILTERING FOR RAPID AND ACCURATE DETECTION OF CW INTERFERENCE ON DIGITAL TELECOMMUNICATIONS
R J Fredericks *In* AGARD Aerospace Telecommun Systems Aug 1972 24 p refs (For availability see N73-10187 01-07)

Application of the quasi linear Kalman filtering algorithm to the problem of estimating the frequency amplitude and, if desired

initial phase of one or more interfering CW signals is described. These unwanted sinusoids are assumed present in a background of noise and the useful signal bandwidth is assumed to be 20-26 kHz with the jammer(s) located anywhere in this spectral interval. Channel center frequencies located throughout the range 100 kHz to 1000 GHz are investigated without requiring any changes in the basic filter structure. While the state dynamics are linear the measurements are highly non-linear functions of the state variables. Because of the non-linearity in the measurements and the fact that the measurement noise is nonwhite various techniques such as the addition of a fourth variable with the dimensions of hertz to the state vector and the use of an adaptive measurement noise matrix are required to insure proper filter convergence. Results are given showing filter operation with J/N ratios from -9db upwards to over +20db. Typical frequency estimation errors after 1000-2000 microseconds with high J/N ratios are on the order of 10 Hz Author

N73-10211 Post Office Research Dept., Ipswich (England)
THE EFFECT OF INTERCHANNEL INTERFERENCE ON THE PERFORMANCE OF A PHASE MODULATED DIGITAL SYSTEM
M C Davies *In* AGARD Aerospace Telecommun Systems Aug 1972 17 p (For availability see N73-10187 01-07)

Computer programs employing simulation and analytical techniques were developed for calculating the error performance of 2- and 4-level coherent-phase-shift keyed (C P S K) and differential-coherent-phase-shift keyed (D C P S K) systems containing filters of specified characteristics. The effect of these filters on the distortion in the wanted channel, and on the probability density and magnitude of the interference were taken into account. Some preliminary 2-level C P S K results from a versatile experimental test facility are in good agreement with the corresponding theoretical results Author

N73-10212 Southampton Univ (England) Dept of Electronics
GENERATION OF INTERMODULATION INTERFERENCE DUE TO NON-LINEAR EFFECTS IN THE NEAR FIELD REGIONS OF MULTIPLE TRANSMISSION COMMUNICATION SYSTEM
J A Betts and D R Ebenezer *In* AGARD Aerospace Telecommun Systems Aug 1972 12 p refs (For availability see N73-10187 01-07)

The co-location of transmitters and receivers for military mobile requirements, particularly when a multiple-frequency transmission capability is essential, produces a serious problem of intermodulation interference. The results of a laboratory investigation in which steel specimens have been subjected to two-frequency excitation (mainly in the HF range at 1.2 and 5.1 MHz) of known field strength and orientation are described. Particular attention has been given to the intermodulation level dependence upon surface preparation, which includes machined and polished, serrated, electrodeposited cadmium and cold-sprayed zinc finishes. Results are also described for stainless, alloy and carbon steels. The effect of surface corrosion, which has hitherto been referred to as the rusty-bolt problem, is also described and its effect within an active transmission system has been distinguished from that on parasitic surfaces Author

N73-10213 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany)
DIRECTIONAL ANTENNAS FOR A NEW INTERFEROMETER SYSTEM (SIDELOBE SUPPRESSION, PHASE CHARACTERISTICS, SUPPRESSION OF GROUND REFLECTIONS)
H Oettl and H Goessl *In* AGARD Aerospace Telecommun Systems Aug 1972 8 p refs (For availability see N73-10187 01-07)

A new interferometer system with antennas mounted on El/Az-pedestals is considered. Each antenna consists of an array of 36 crossed dipoles. There is a Tschebyscheff amplitude distribution in the elevation plane and in the plane orthogonal to it. Since the distance between the three interferometer antennas is 57 lambda, the suppression of reflected signals must be better than 40 to 50 db to keep the phase error due to reflections in the order of 0.1 deg. A further method of suppressing ground reflections, i.e. the use of concentric wire-mesh fences around each antenna, is also mentioned. Another error of the antenna system is the phase pattern discrepancies between

N73-14131# Advisory Group for Aerospace Research and Development, Paris (France)
EFFECTS OF ATMOSPHERIC ACOUSTIC GRAVITY WAVES ON ELECTROMAGNETIC WAVE PROPAGATION
Oct 1972 508 p refs In ENGLISH, partly in FRENCH Presented at Specialist Meeting of the Electromagnetic Wave Propagation Panel of AGARD, Wiesbaden, 17-21 Apr 1972
(AGARD-CP-115) Avail NTIS HC $27.50

The generation, propagation, and effects of acoustic gravity waves on atmospheric transmission of electromagnetic waves are discussed. The formation of traveling ionospheric disturbances and their influence on radioelectric communications are emphasized. For individual titles, see N73-14132 through N73-14170

N73-14132 National Oceanic and Atmospheric Administration, Boulder, Colo Space Environment Lab
SOME ANALOGIES BETWEEN THE PROPAGATION OF IONOSPHERIC RADIO WAVES AND ACOUSTIC-GRAVITY WAVES
Kenneth Davies *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 12 p refs (For availability see N73-14131 05-07)

The propagation of radio waves in the ionosphere is similar to that of acoustic gravity waves in the neutral atmosphere. Both are anisotropic and dispersive. Furthermore the temperature structure in the atmosphere is somewhat similar to the electron density structure in the ionosphere. Ray tracing of acoustic waves exhibit high- and low-angle rays, skip zones, etc Author

N73-14133 National Oceanic and Atmospheric Administration, Boulder, Colo Wave Propagation Lab
A 3D TRACING FOR ACOUSTIC-GRAVITY WAVES
T M Georges *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 10 p refs (For availability see N73-14131 05-07)

A new general purpose ray tracing program for acoustic gravity waves has been developed. It allows atmospheric wind and temperature to vary in all three spatial dimensions and with time and accounts for earth curvature. Ray plots show the characteristic acoustic ray patterns of a standard atmosphere but also some interesting and unexpected ray geometries in cases of more complex wind fields and for internal gravity waves Author

N73-14134 National Bureau of Standards, Washington, D C
GENERATION AND PROPAGATION OF SOUND WAVES BETWEEN THE IONOSPHERE AND THE LOWER ATMOSPHERE
Richard K Cook *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 8 p refs (For availability see N73-14131 05-07)

Various physical processes generate sound waves at infrasonic frequencies in the lower atmosphere. The results of an analysis for the generation of sound and propagation downwards due to the heating effects of auroral discharges, particularly those traveling at supersonic speeds in directions parallel to the earth's surface are presented. The shock waves from such discharges are propagated steeply downward with very little loss of energy from absorption by viscosity and heat conduction, and are frequently observed at infrasonic stations located at high latitudes. An estimate of auroral heating is derived from the observed strengths of infrasound at the earth's surface Author

N73-14135 Massachusetts Inst of Tech, Cambridge Dept of Mechanical Engineering
A MODEL FOR ACOUSTIC-GRAVITY WAVE EXCITATION BY BUOYANTLY RISING AND OSCILLATING AIR MASSES
Allan D Pierce *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972

12 p refs (For availability see N73-14131 05-07)
(Contract F19628-70-C-0008)

A somewhat general mathematical model is developed for the study of the excitation of acoustic-gravity waves by rising and oscillating air masses. Sources are initially described by distributions of fluid dynamic quantities over a moving closed surface. Analysis then indicates that insofar as wave generation is concerned, such surface distributions are equivalent to concentrated point sources at the center of the volume. The resulting linearized inhomogeneous wave equations are derived and solved in terms of Green's functions. The case of an isothermal atmosphere is discussed in some detail. Author

N73-14136 Imperial Coll. of Science and Technology, London (England)

ACOUSTIC GRAVITY WAVES AND DIFFUSION EFFECTS AT THE ATMOSPHERIC BOUNDARIES

F. W. G. Warren *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct. 1972 8 p refs (For availability see N73-14131 05-07)

The boundary conditions in the linear theory of acoustic gravity waves in the atmosphere are discussed. It is shown that diffusion effects at the boundaries may for the most part be ignored provided the vertical wave number is not too small. The results for gravity waves agree qualitatively with those obtained by Yanowitch (1967) but the details differ. An upper bound for the reflexion coefficient for small vertical wave numbers is obtained. It is recalled that the results hold only if the mean free path at high altitudes is small compared with the horizontal wavelength. Author

N73-14137 Alaska Univ., College. Geophysical Inst.

AURORAL INFRASONIC WAVE GENERATION MECHANISM

Charles R. Wilson *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct. 1972 20 p refs Sponsored in part by ARPA and NOAA (For availability see N73-14131 05-07)
(Grant NSF GA-16821)

The morphology of auroral infrasonic wave (AIW) substorms as determined from infrasonic observations along a magnetic meridian through Alaska, shows that AIW are never observed propagating in a poleward direction even though auroral activity frequently occurred south of the stations. AIW have been shown to be infrasonic bow waves generated by supersonic westward, equatorward or eastward motions of auroral electrojet arcs. This asymmetry in the occurrence of AIW with respect to direction of motion of an arc is interpreted as an intrinsic asymmetry in the generation mechanism within the auroral arcs and not as a propagation effect. It is postulated that the basic acoustic pulse within the electrojet arcs is caused by collisions with the neutral gas of positive ions that are driven by electrodynamic drift in the E region of the auroral arc. If the supersonic translation of the primary auroral electron sheet has a component of motion parallel to the electrodynamic drift of the positive ions, then an auroral infrasonic shock wave will be produced in the E region ionosphere and propagate to the ground as a modified shock or bow wave. If on the other hand the auroral arc motion is anti-parallel to the drift of the positive ions, then no AIW will be produced. Author

N73-14138 Kiruna Geophysical Observatory (Sweden)

DETECTION OF 2 Hz INFRASOUND PRODUCED BY MOVING AURORAL ELECTROJETS

Ludwik Liszka and Hans Westin *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct. 1972 12 p refs (For availability see N73-14131 05-07)

Two Hz infrasound was detected during a number of major geomagnetic storms using microphone arrays. The direction of arrival and the horizontal phase velocity of the infrasound at the microphone arrays were obtained. These quantities were compared with motions of the auroral electrojet as determined from geomagnetic observations at five Scandinavian stations. The comparison, using a ray tracing technique, has shown that only a part of the observed infrasound may be produced by supersonic motions of auroral electrojets. Author

N73-14139 Illinois Univ., Urbana. Ionosphere Radio Lab.

ON WAVES GENERATED BY STATIONARY AND TRAVELING SOURCES IN AN ISOTHERMAL ATMOSPHERE UNDER GRAVITY

C. H. Liu and K. C. Yeh *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct. 1972 17 p refs (For availability see N73-14131 05-07)
(Grant NSF GA-13723)

Experimental evidence indicates that acoustic gravity waves in the neutral atmosphere can be generated by various natural and artificial sources such as earthquakes, severe weather fronts, nuclear detonations in the atmosphere, jet streams, supersonic displacements of auroral arcs, auroral substorms, solar eclipse, jet aircrafts, rocket launchings, etc. These various excitation mechanisms can be considered as one or a combination of the three types of sources: mass production, momentum production and energy production which can be studied in a very general fashion. For the case of stationary sources it is shown that the transient response and the overall wave form at a given observation point depend on a number of parameters such as the height and the range of the observation point, the time of observation, the spatial and temporal dependence of the source, the nature of source, etc. Author

N73-14140 Lamont-Doherty Geological Observatory, Palisades, N.Y.

ACOUSTIC GRAVITY WAVES IN THE NEUTRAL ATMOSPHERE AND THE IONOSPHERE

Nambath K. Balachandran *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct. 1972 11 p refs (For availability see N73-14131 05-07)
(Contract DAAB07-69-C-0256; Grants DA-ARO(D)-31-124-71-G90; NSF GA-17454)
(Contrib. 1799)

Acoustic gravity waves from nuclear explosions are detected at large distances from the source by sensitive microbarograph on the ground, by high frequency Doppler technique at ionospheric levels and by long period seismographs. The dispersion of acoustic gravity waves at the ground level is explained by using normal mode approach for a stratified atmosphere. For acoustic gravity waves detected at the ground level, the short period acoustic modes have higher amplitudes than the long period gravity modes when stratospheric winds are in the direction of propagation of the waves. Dopplersonde records of ionospheric disturbances show more predominance of shorter period acoustic modes than the gravity modes. According to the normal mode theory and the Lamb wave theory, the energy density for long period waves decreases exponentially with height from the ground, thus providing insufficient energy for ionospheric disturbances. Author

N73-14141 Mount Auburn Research Associates, Inc., Newton Upper Falls, Mass.

MODELING OF NUCLEAR SOURCES OF ACOUSTIC-GRAVITY WAVES

Brian L. Murphy and Sheldon L. Kahalas *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct. 1972 17 p refs (For availability see N73-14131 05-07)
(Contract F44620-71-C-0086)

The relationship between hydrodynamic motions caused by a low altitude explosion and subsequent ionospheric disturbances is reviewed. Both the upward going shock and the rising fireball are considered as hydrodynamic sources. It is shown that different portions of the shock front may be classified in terms of the ionospheric disturbance they create. The portion of the shock front reflected from the 100-120 km altitude level produces disturbance periods the order of a minute for a megaton detonation. The portion of the shock front which propagates above the 100-120 km level is responsible, through a complex nonlinear process, for disturbance periods in excess of 10 minutes. It is shown that the fireball is most efficient in generating acoustic gravity waves when it reaches its stabilization altitude and approaches hydrodynamic equilibrium with the atmosphere. Author

N73-14142 Ecole Normale Superieure, Paris (France) Lab de Physique

THE THEORY OF ATMOSPHERIC ACOUSTIC PROPAGATION

Ch Berthet and Y Rocard *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 18 p In FRENCH, ENGLISH summary (For availability see N73-14131 05-07)

A comprehensive review of atmospheric acoustic wave propagation is reported Calculations demonstrate the radiating properties of the infrasonic noise ring created by large explosions on the ground in directions other than those of the rays which formed it Introduction of nonlinearity in the propagation of infrasonic short period waves results in the bending of acoustic rays back to the ground Author

N73-14143 Massachusetts Inst of Tech Cambridge

EXPLOSIVE EXCITATION OF LAMB'S ATMOSPHERIC EDGE MODE

Joe W Posey and Allan D Pierce *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 12 p refs (For availability see N73-14131 05 07)
(Contract F19628-70-C-0008)

It has been previously demonstrated that far field ground level pressure observations of explosively generated acoustic gravity waves are often dominated by the Lamb atmospheric edge mode for the first cycle or two Particular attention is given to the excitation of this mode by a blast wave from a large atmospheric explosion It is found that the strength of the excitation is strongly dependent upon the tail of the blast wave A theoretical development shows that for the pure Lamb mode, a simple analytical relation exists between the energy of the source and the initial amplitude and period of the far field pressure waveform This relation is compared with some empirical data and appears to be in fair agreement with yield estimates based on seismic observations Author

N73-14144 Stanford Research Inst Menlo Park, Calif

JUSTIFICATION FOR THE USE OF HINES' ASYMPTOTIC RELATIONS FOR TRAVELING IONOSPHERIC DISTURBANCES

Norman J F Chang *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 10 p refs (For availability see N73-14131 05 07)

It is shown that internal gravity waves propagating at ionsopheric heights must have propagation angles near the maximum permitted Thus, for traveling ionospheric disturbances (TIDs) the use of Hines' asymptotic relations is justified by ray tracing Verification of these relations is made by comparison of theoretical with experimental results for fifteen TIDs The effects of the temperature profile on the measurable properties of TIDs (wavefront tilts and periods) are discussed It is shown that for TIDs that originate below the mesopause, the atmosphere behaves like a bandpass filter with center frequency favoring waves with periods near 20 minutes Author

N73-14145 Max-Planck-Institut fuer Aeronomie Lindau Uber Northeim (West Germany) Inst fuer Ionosphaerenphysik

FULL WAVE CALCULATIONS OF ELECTRON DENSITY PERTURBATIONS CAUSED BY ATMOSPHERIC GRAVITY WAVES IN THE F2 LAYER

J Klostermeyer *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 11 p refs (For availability see N73 14131 05 07)

The coupled systum of hydrodynamic equations which describes gravity wave perturbations in the neutral and ion gases is solved by a full wave method including the effects of height dependent temperature and winds Coriolis force, viscosity, thermal conduction, and ion drag Calculated results agree well with experimental data deduced from vertical incidence ionograms The numerical calculations are further combined with observed gravity wave parameters to obtain height profiles of the amplitude and phase of the electron density perturbation as functions of the geomagnetic inclination and the azimuth of wave propagation The calculated perturbation depends very strongly on height, inclination, and azimuth Its amplitude varies between 0 and 100 per cent of the undisturbed electron density, and its phase may change rapidly around the F-layer maximum Author

N73-14146 Queensland Univ, Brisbane (Australia) Dept of Physics

ATMOSPHERIC PRESSURE WAVES AT BRISBANE AND THEIR ASSOCIATION WITH CERTAIN IONOSPHERIC AND SOLAR EVENTS

G G Bowman *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 13 p refs (For availability see N73 14131 05 07)

Two aspects of the nighttime recordings, at Brisbane, of microbarographs of high sensitivity are examined when the records showed well defined gravity waves with periods around 12 minutes and amplitudes of the order of 10 microbar Superposed-epoch analyses using these occurrences as control dates, for a sunspot minimum period revealed an apparent association between the dates and the occurrence of ionospheric spread F conditions in sub-auroral regions of the earth Also when sunspot activity and geomagnetic activity were plotted relative to these dates, there was evidnece of 27 day periodicities in the distributions Some gravity wave occurrences are shown to be related to the passage of weather fronts at Brisbane However, it is the remaining occurrences which appear to be associated with the occurrence of spread F Some evidence for an association between the occurrence of atmospheric acoustic waves and sunspot activity is developed Author

N73-14147 National Oceanic and Atmospheric Administration Boulder Colo Space Environment Lab

FURTHER REMARKS ABOUT TRAVELING IONOSPHERIC DISTURBANCES ATTRIBUTED TO JET STREAM ACTIVITY AT MID-LATITUDE

G B Goe *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 13 p refs (For availability see N73 14131 05 07)

Medium scale traveling ionospheric disturbances with periods of 12 to 30 minutes are detected during daytime winter at F region heights These disturbances are present when it is magnetically quiet and are attributed to the presence of active wind patterns associated with the jet stream at the height of the tropopause The active patterns on the tropopause wind analysis maps are recognized by horizontal wind shear as the direction of flow lies parallel to the isolines of constant wind speed The activity diminishes as the wind accelerates or decelerates in the direction of flow The ionospheric activity resulting from these active tropopause winds may be thought of as localized in terms of global circulation and hence is neither observed nor predicted on a global scale This is unfortunate as HF radio transmission is effected by the presence of such ionospheric disturbances Author

N73-14148 Massachusetts Inst of Tech Cambridge

GENERATION OF ANOMALOUS IONOSPHERIC OSCILLATION BY THUNDERSTORMS

C A Moo and A D Pierce *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 8 p refs (For availability see N73 14131 05 07)
(Contract F19628 70 C 0008)

Radio HF Doppler sounding of the ionosphere shows oscillations during periods of thunderstorm activity These oscillations have periods in the range of 2 min to 5 min frequently for many hours duration The coherence of the oscillations is consistent with the interpretation generally given that they are caused by the passage of long wavelength infrasonic waves There are apparently no similar distinct oscillations with the same period range associated with air motion in the troposphere during severe weather However convective activity is known to generate fluctuations and internal waves with periods near and above Brunt Vaisala periods A theory for the generation of these ionosphere 2 to 5 min period waves based on concepts similar to those used by Lighthill in the theory of aerodynamic sound is proposed Author

N73-14149 Max-Planck-Institut fuer Aeronomie, Lindau Uber Northeim (West Germany)

A PHENOMENOLOGICAL INVESTIGATION OF AMPLITUDES AND SPECTRA OF GRAVITY WAVES

J P Schoedel *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 13 p refs (For availability see N73-14131 05-07)

Observations of the ionospheric electron content by means of geostationary beacon satellites very often exhibit oscillations of sinusoidal form Faraday rotation records represent a good monitoring system for these oscillations For the investigation of the oscillations the records of the electron content were filtered numerically The amplitudes of effects caused by gravity waves can easily be demonstrated after the filtering The filtered part of the data - representing the wave induced fluctuations - can be used for the computation of power spectra The following facts are found (1) The wave amplitude decreases rapidly with decreasing period length, (2) all periods can be observed, and (3) harmonic frequencies are usually not observed Author

N73-14150 Stanford Research Inst, Menlo Park, Calif Radio Physics Lab

COMPARISON OF COMPUTED AND OBSERVED SHOCK BEHAVIOR FROM MULTIKILOTON, NEAR-SURFACE NUCLEAR EXPLOSIONS

Demetri P Kanellakos and Raymond A Nelson *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 16 p refs (For availability see N73-14131 05-07)

(Contracts F33657-68-C-1147, F33657-70-C-0090)

Comparisons are made between numerical hydrodynamic calculations of the propagation through the ionosphere of shock fronts arising from near surface nuclear explosions and experimental observations of the ionospheric disturbances associated with these shock fronts The purpose of these comparisons is to provide a test of the validity of numerical hydrodynamic calculations at ionospheric heights Experimental values obtained from ionograms taken for some nuclear test series clearly show an acceleration of the shock front at altitudes above 100 km There is agreement between experimental and calculated values to within a few km for the primary shock front in spite of a lack of knowledge of the exact atmospheric parameters at the times of the tests Author

N73-14151 National Oceanic and Atmospheric Administration, Boulder Colo Wave Propagation Lab

FM CW RADAR STUDIES OF PRODUCTION OF TURBULENT INSTABILITY WITHIN THERMALLY STABLE LAYERS BY INTERNAL WAVES

Earl E Gossard and J H Richter (Naval Electron Lab Center) *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 16 p refs (For availability see N73-14131 05-07)

A recent development in radar sounding has made the detailed structure of the troposphere visible to a degree previously not approachable The radar sounder is an FM CW system The most outstanding features evident in the records are internal gravity waves features resembling Kelvin Helmholtz instability structures multiple layering often displaying lamina only a few meters thick, and convection cells within the marine layer A variety of atmospheric structural patterns are shown and compared with several hypothetical models of internal wave structures to obtain more insight into the atmospheric processes at work Special attention is given to the distribution of Richardson's number in trapped and untrapped gravity waves It is concluded that the multiple layers result from untrapped internal gravity waves whose propagation vector is directed nearly vertically within very stable height regions Author

N73-14152 Applied Physics Lab Johns Hopkins Univ, Silver Spring Md

THE DETECTION AND STUDY OF GRAVITY WAVES WITH MICROWAVE RADAR

Isadore Katz *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 11 p refs Sponsored in part by AFCRL (For availability see N73-14131 05-07)

The use of ultra sensitive radars has resulted in a new ability to see structure and motion of the atmosphere not possible before Among other things these radars detected gravity waves at the tropopause Experimental proof has been obtained which shows incontrovertible evidence that Bragg scattering is the prime cause of the electromagnetic scattering phenomenon The signal strength of the radar echoes was found to be a linear function of the spectral density of refractive index fluctuations in the atmosphere A review of 26 gravity wave cases permits a tentative characterization of these waves in terms of sizes, shapes, persistence and conditions under which they occur Author

N73-14153 Politecnico di Torino (Italy) Ist di Elettronica e Telecomunicazioni

OBSERVATIONS OF GRAVITY WAVES IN THE HEIGHT RANGE

G E Perona *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 10 p refs (For availability see N73-14131 05-07)

Acoustic gravity waves can successfully be detected in the D region of the ionosphere in spite of all the well known difficulties that characterize the interpretation of the data concerning that region This possibility is demonstrated from a theoretic point of view and is successively confirmed by a careful analysis of VLF data and cross modulation data, related to the 50-70 km range The limits on the amplitude, frequency and wavelength of acoustic gravity waves that may be detected at these levels are outlined Author

N73-14154 Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France)

OBSERVATIONS OF GRAVITY WAVES IN THE HIGHER ATMOSPHERE BY MEANS OF METEOR TRAIN DETECTION

M Glass (Lab de Phys de l'Ecole Normale Superieure) A Spizzichino, and I Revah *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 16 p refs In FRENCH, ENGLISH summary (For availability see N73-14131 05-07)

Over 1000 individual values of neutral wind can be obtained daily, within the 75-105 altitude range, with a meteor radar Data processing and harmonic analysis significantly exhibit progressive waves whose vertical propagation can be tracked owing to the accuracy in location due to the radar The length of the measurement period (10 days) makes it possible to acquire data on the life duration of the gravity waves observed Returns from ionized traces produced by meteorites penetrating into the higher atmosphere are also obtained The radar is extremely sensitive and therefore can detect over 1000 meteor echoes daily Owing to a novel device for measuring the distance between the radar and the meteor echo, and to the accurate determination of the elevation and azimuth of this echo the altitude can be determined within + or - 500 meters The motions of the east-west component of the neutral wind within the 75-105 altitude range can be deduced from the Doppler effects on these echos Waves are thus exhibited whose vertical propagation can be tracked since the altitude is known Besides tidal motions, with periods ranging from 12 to 24 hours and over shorter period oscillations are observed which can be compared to gravity waves Author

N73-14155 Alaska Univ, College Geophysical Inst

NARROW BEAM HF RADAR INVESTIGATIONS OF MIDLATITUDE IONOSPHERIC STRUCTURE AND MOTION

Robert D Hunsucker *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 14 p refs (For availability see N73-14131 05-07)

Data acquired from 1964 - 1968 with a narrow-beam azimuth and elevation scan high frequency backscatter sounder have been analyzed in detail This analysis has revealed that the irregular structure of the midlatitude ionosphere is the rule rather than

the exception Irregularities of varying scale size and apparent motion were present in about 90% of the observations The signatures observed by this HF radar system have been categorized into eight generic types which have been labelled with names roughly describing their appearance on the range-azimuth scan record The relative diurnal and seasonal occurrence as well as the qualitative sunspot cycle and geomagnetic correlation of these signatures are presented One particular type of signature was analyzed using a three dimensional computer ray tracing technique utilizing experimental data to modify an atmospheric gravity wave disturbance model The synthetic backscatter record was sufficiently similar to the experimental HF radar record to justify this approach in the interpretation of backscatter data
Author

N73-14156 Centro Radioelettrico Sperimentale G Marconi, Rome (Italy)
AN IMPORTANT CHARACTERISTIC OF SOME TRAVELING IONOSPHERIC DISTURBANCES
I Ranzi and P Giorgi *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 2 p (For availability see N73 14131 05-07)

The observation of the F 2 region winter TIDs by means of vertical sounding on a fixed frequency, showed that the occurrence time of some TID groups anticipates from day to day Author

N73-14157* Alabama Univ Research Inst Huntsville
IONOSPHERIC DISTURBANCES CAUSED BY LONG PERIOD SOUND WAVES GENERATED BY SATURN-APOLLO LAUNCHES
Ganti L Rao *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 11 p refs (For availability see N73 14131 05-07)
(Contract NAS8 27088)

Wavelike disturbances were observed in the ionosphere following several nuclear explosions in early 1960's Supersonic shock waves within the atmosphere generated by large rockets can cause ionospheric electron density perturbations A CW phase path Doppler array in the New York area was operated during the Saturn Apollo 12 and 13 launches and recorded Doppler frequency fluctuations due to rocket launchings Cross correlation and power spectral analyses of the phase path Doppler frequency variation records showed that the phase velocities of the signal arrivals were from south of the array with 700 800 m sec corresponding to periods in the range of 2 to 4 minutes Ionograms taken every 60 seconds from Wallops Islands showed clearly ionospheric disturbances due to rockets The group velocities were estimated to be of the order of 450 m sec 1 obtained from the earliest visible disturbances seen on CW phase path Doppler records and ionograms together with the rocket trajectory data
Author

N73-14158 Communications Research Centre Ottawa (Ontario) Dept of Communications
OBSERVATIONS OF TRAVELLING IONOSPHERIC DISTURBANCES AT LONDON, CANADA
J Litva *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 23 p refs (For availability see N73 14131 05-07)

Observations of travelling ionospheric disturbances were obtained by way of a new technique which is described in detail, namely measurement of angle of arrival and amplitude variations of radio waves which propagated through the ionosphere from localized regions of enhanced emission on the solar disk The observations reported here show good evidence of TID wave trains consisting of 15 to 18 wave cycles The angular deflections of the solar line of sight at 51 7 MHz were measured to be between plus or minus 6 to plus or minus 20 minutes of arc from which electron number density perturbations are calculated to be of the order of 1 to 2 percent The observed variations in amplitude corresponding to the larger angle of arrival scintillations were about 5 db The TIDs were primarily of two types one with a period of approximately 6 minutes the other with a period of 21 minutes The former travelled with the speed of about 200 km hr and a corresponding wave length of 20 km The speed of the latter was between 800 and 2000 km hr and the corresponding wavelength between 300 and 700 km they also had a preferred line of travel which was orientated north south
Author

N73-14159 Government Communications Hq Cheltenham (England)
THE EFFECT OF IONOSPHERIC DISTURBANCES ON THE BEARINGS OF INCOMING SKY WAVES
A D Morgan *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 19 p refs (For availability see N73-14131 05-07)

A series of experiments was conducted to examine the effects of TIDs on bearing measurements The receiving aerial used was a circularly disposed wide aperture array and the output from the array was processed by an automatic bearing measuring equipment The results showed that the bearing fluctuated with periods of the order of 20 minutes On some days, the bearing record showed a continuous sequence of these fluctuations whereas on other days, the fluctuations were almost absent On the assumption of a mirror type of reflection, the observed bearing error for a single hop path corresponded to ionospheric tilts of up to 9 degrees Further on this assumption, it is estimated that these tilts can change at the rate of up to one degree per minute The results also suggest the presence of systematic tilts in the ionosphere, which change with the diurnal change of the solar zenith angle The implications of these results, on practical radio communication, are briefly discussed
Author

N73-14160 Weapons Research Establishment, Salisbury (Australia)
IONOSPHERIC TILT MEASUREMENTS NEAR THE MAGNETIC DIP EQUATOR
R F Treharne *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 13 p refs (For availability see N73-14131 05-07)

Observations of ionospheric tilt have been made near the magnetic dip equator During the daytime these observations were hindered by the continuous presence of the intense irregularities in the E region but the observed tilts appeared to be larger and to have a systematic tilt not seen in temperate latitudes, the bias was to the east during the daytime and reversed in direction at sunset during the equinoctial months During the evening, if spread F was absent, the tilts of the F region could be observed more clearly These evening tilts were of much greater magnitude, had a much longer time scale than in temperate latitudes, and had superposed faster variations of a smaller scale which might be attributed to gravity waves Three nights of observations are available one in winter, two in summer In all three cases the maximum tilt (9 degrees) occurred near 2100 hours local time, the time normally associated with the equatorial rise in h'F after sunset but in the first case (winter) the direction was north, whereas in the second (summer) it was west and in the third (also summer) it was east
Author

N73-14161 Kiruna Geophysical Observatory (Sweden)
ON THE GENERATION AND DETECTION OF ARTIFICIAL ATMOSPHERIC WAVES
Ludwik Liszka and Sixten Olsson *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 11 p refs (For availability see N73-14131 05-07)

Preliminary results of detection of atmospheric waves produced by focussing of shocks generated by supersonic aircraft are presented The flight trajectories were chosen so that the acoustic gravity waves following the shock front were focussed on the ground after reflection from the stratosphere or in the E layer Infra acoustic waves were detected on the ground using a 2 Hz infra-acoustic correlator At the E layer the waves were detected using a modified vertical sounding technique Results obtained during 11 test flights have shown that the ray tracing technique may be successfully used for predicting the propagation of atmospheric waves following shock fronts
Author

N73-14162 Northeastern Univ Boston Mass
AN APPROACH TO THE ANALYSIS OF COUPLING

BETWEEN ACOUSTIC-GRAVITY WAVES AND ELECTROMAGNETIC WAVES
H R Reemer *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 12 p refs (For availability see N73-14131 05-07)

The development of theoretical models for plasma media whose parameters are spatially variable, and the use of these models to study wave propagation in such media with the aid of high speed computers is reported Some of these theoretical models can be used to study the first-order effects of a low frequency wave disturbance (e.g. an acoustic gravity wave at a fraction of a Hertz) on a high frequency electromagnetic wave (at kilohertz or megahertz) propagating in the ionosphere The formulation of the model and its adaptation to the problem of interest via perturbation theory are first described, followed by a general outline of the way in which this theory can be used to calculate the first order effects of the acoustic gravity wave on the electromagnetic wave Some communication systems implications of this theory are briefly discussed at the end of the paper Author

N73-14163 Weapons Research Establishment, Salisbury (Australia)
HF RAY TRACING OF GRAVITY WAVE PERTURBED IONOSPHERIC PROFILES
P L George *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 17 p refs (For availability see N73-14131 05-07)

The results of a computer simulation of the direction of arrival of short range ionospheric radio ray paths in the presence of a medium scale travelling ionospheric disturbance (TID) are reported The analytical representation of the TID is based both on actual observations of such disturbances and upon the theory of internal atmospheric gravity waves Computed results of the time dependence of direction of arrival and Doppler shift such as would be observed at a ground based station, show good qualitative agreement with observations The relationship between the computed direction of arrival variations and certain characteristics of the TID model that produced them is examined at a low latitude and at a high latitude location The accuracy of a simple geometrical model that has been proposed for tilt correction of apparent direction of arrival is evaluated It is shown how the uncertain results derived from use of this model may be substantially improved by taking into account the direction of travel, velocity and scale of the TID, these parameters being derived by continuous observation at spaced stations Author

N73-14164 Max-Planck-Institut fuer Aeronomie, Lindau Uber Northeim (West Germany)
SOME EFFECTS OF ATMOSPHERIC GRAVITY WAVES OBSERVED ON A TRANSEQUATORIAL RADIO PATH
J Roettger *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 17 p refs (For availability see N73-14131 05-07)

The influence of atmospheric gravity waves on the point-to-point propagation of HF radio waves in the ionosphere is investigated for two cases The gravity waves are propagating in direction of the great circle between two points, and the gravity waves are propagating transverse to the great circle direction Measurements on a north-south directed transequatorial HF radio path using fixed frequency CW transmitters show periodical field strength variations during nighttime hours, which are assumed to be caused by focussing due to north-south propagating atmospheric gravity waves Ray tracing calculations prove that periodical focussing can occur when ionospheric profiles perturbed by atmospheric gravity waves are employed A power density analysis of the recorded field strength patterns is carried out in order to obtain indications about the main fading periods Variations in propagation time and azimuth angle indicate traveling ionospheric disturbances moving from west to east in the equatorial zone Author

N73-14165 National Oceanic and Atmospheric Administration, Boulder, Colo Space Environment Lab
PROPAGATION OF SUBMICROSECOND HF PULSES THROUGH TRAVELLING IONOSPHERIC DISTURBANCES
G M Lerfald, R B Jurgens, and J A Joselyn *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 21 p refs (For availability see N73-14131 05-07)
(ARPA Order 1361)

HF pulses of submicrosecond duration, received at a range of 1500 km after a single ionospheric reflection from the F region, have been analyzed to study the effects imposed on the pulses by the propagation process The recorded pulses display a wide variation in form One pulse characteristic is the pulse stretching attributable to ionospheric dispersion Typically, for a 1 MHz receiver, the recorded pulse has a duration of about 15 msec Frequently the recorded pulses also display structure due to polarization splitting and to the reception of time-shifted wavetrains from multiple reflection points (multipath) Some results from the statistical analysis of a large number of pulses include (1) Occurrence distributions of pulse lengths yield effective ionospheric dispersion rates, (2) time series plots of pulse delay give the amplitude and period of changes in group path, (3) pulse characteristics typically do not change much on a time scale of a few seconds but often change markedly in a few minutes, and (4) detailed analysis of selected pulses shows that the time shifts of multipath components could be derived for the simpler cases Author

N73-14166 Uppsala Ionospheric Observatory (Sweden)
TRAVELLING IONOSPHERIC DISTURBANCES INITIATED BY LOW ALTITUDE NUCLEAR EXPLOSIONS
W Stoffregen *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 9 p refs (For availability see N73-14131 05-07)

Ionospheric disturbances travelling with a maximum velocity of approximately 630 m/s were recorded over the Scandinavian area after two large nuclear explosions The disturbances in the ionosphere were most pronounced in the F region, as is evident from the ionograms and real height profiles When the first wave arrived, a spontaneous increase of the height of the F2 layer was observed, followed by splitting of the F layer and a slower phase of recovery At the E level, a sporadic E layer occurred with some delay and the D region ionization increased during two short periods with a delay of about one hour with respect to the disturbance in the F layer The time delay of the disturbances at different levels of the ionosphere can be explained by the results of ray tracing studies of the propagation of acoustic gravity waves Author

N73-14167 Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France)
IONOSPHERIC DISTURBANCES GENERATED BY ACOUSTIC-GRAVITY WAVES RESULTING FROM A 100 kt TO 2000 kt NUCLEAR EXPLOSION ON THE GROUND, OBSERVED AT POINTS LOCATED BETWEEN 160 AND 1000 km FROM THE FIRING SITE
P M Halley *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 2 p (For availability see N73-14131 05-07)

During French nuclear experiences in Polynesia, travelling ionospheric disturbances were observed and their impact on high frequency band propagation was investigated Various recordings of Doppler effect frequency shifts and of vertical or oblique soundings are interpreted as exhibiting mainly two disturbance components (1) A rapid component which is a thermospheric wave whose instantaneous speed is approximately 720 m/s at a horizontal distance of 290 km and then diminishes as the distance increases This oscillation wave may appear at a very great distance, where its velocity always exceeds 400 m/s (2) A low component which could be a ground wave or a guided wave whose velocity is about constant and of the order of 305 m/s This wave rises up to ionospheric altitudes where it becomes superimposed on the thermospheric wave The impact of such a disturbance on oblique propagation and the resulting impairment of telecommunication possibilities are discussed Author

N73-14168 Paris Univ (France) Lab de Physique de l'Exosphere
NONLINEAR PROPAGATION AND IONOSPHERIC COUPLING OF ATMOSPHERIC WAVES GENERATED BY A NUCLEAR EXPLOSION
P Broche (Centre Univ de Toulon) *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 13 p refs In FRENCH, ENGLISH summary (For availability see N73-14131 05-07)

The disturbance generated in the ionosphere by a nuclear explosion was observed at several points, using the method which consists in measuring the Doppler effect on a HF radio transmission. Two aspects of the results are stressed (1) The time delay in the occurrence of the disturbance shows that its propagation between the ground and the ionosphere is nonlinear and makes it possible to define a numerical model to describe it, and (2) the time spectrum confirms the considerable influence of the geomagnetic field on the coupling between the motions of neutral particles and those of ionized particles Author

N73-14169 Stanford Research Inst, Menlo Park, Calif
NUCLEAR WEAPON EFFECTS ON THE IONOSPHERE (F-REGION DISTURBANCES)
J B Lomax and D L Nielson *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 12 p ref (For availability see N73-14131 05-07)
(Contract DA-36-039-SC-87197)

The detonation of a nuclear burst at ionospheric heights causes a multiplicity of effects in the ionosphere and therefore on HF communications Sequences of contour maps of critical frequency are presented in a 16-mm sound, color movie, showing the variation of the F layer maximum electron density as a function of time and space following high altitude nuclear tests The maps encompass the region 30 deg north and south from the magnetic equator and 35 deg east and west from Johnston island The principal effect illustrated is the propagation of ionospheric waves radially outward from the point of detonation The theory of hydrodynamical waves is also discussed and illustrated in the film, and the observed characteristics of ionospheric waves are presented Author

N73-14170 Stanford Research Inst, Menlo Park, Calif
THE EFFECTS OF NUCLEAR-BURST-PRODUCED ACOUSTIC GRAVITY WAVES ON HF COMMUNICATION SYSTEMS
D L Nielson *In* AGARD Effects of Atmospheric Acoustic Gravity Waves on Electromagnetic Wave Propagation Oct 1972 15 p refs (For availability see N73-14131 05-07)

Acoustic gravity waves generated by high altitude nuclear explosions can momentarily affect the performance of HF communications Two changes can occur (1) the available propagation spectrum may at some point decrease such that the circuit is no longer operative at a given frequency, and (2) the time-delay and frequency distortions may increase the likelihood of error in a digital system All effects are subject to the relative orientation of the path, the source, and the geomagnetic field as well as the state of the ionosphere along the path Author

N73-23108# Advisory Group for Aerospace Research and Development, Paris (France)
RADOMES, ADVANCED DESIGN
O Tornani, ed Mar 1973 157 p refs
(AGARD-AR-53) Avail NTIS HC $10.00

The techniques of radome design are summarized and a model for radome specifications is presented The subjects discussed are (1) environmental design, (2) electrical design, and (3) materials for radome design Graphs are developed to show radome characteristics under various conditions Mathematical models are developed to support the theoretical considerations Author

N73-26121# Advisory Group for Aerospace Research and Development Paris (France)
TELECOMMUNICATIONS ASPECTS ON FREQUENCIES BETWEEN 10 AND 100 GHz
Albert W Biggs, ed (Kansas Univ, Lawrence) Apr 1973 246 p refs Presented at Electromagnetic Wave Propagation Panel Tech Meeting, Gausdal, Norway, 18-21 Sep 1972
(AGARD-CP-107) Avail NTIS HC $14.50

The general loss mechanisms of ultrahigh frequency telecommunication systems are studied Considered are effects of atmospheric absorption and rainfall on radio transmission For individual titles, see N73-26122 through N73-26143

N73-26122 Washington Univ, Seattle Dept of Electrical Engineering
MULTIPLE SCATTERING EFFECTS ON WAVE PROPAGATION THROUGH RAIN
Akira Ishimaru and James C Lin *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 13 p refs (For availability see N73-26121 17-07)

The multiple scattering effects of a wave propagating through rain are studied In particular the variances of the in phase and quadrature components of the wave fluctuation are presented taking into account the beam width of the transmitter and receiver and the scattering and absorption characteristics of a single particle Expressions for the temporal frequency spectra of the in-phase and quadrature components are formulated taking into account the terminal velocities of the rain drops Author

N73-26123 Politecnico di Milano (Italy) Inst di Elettrotecnica ed Elettronica
DEPOLARIZATION OF AN ELECTROMAGNETIC WAVE TRAVELING THROUGH A STRATIFIED AEROSOL ON NONSPHERICAL SCATTERING
C Capsoni and A Paraboni *In its* Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 16 p refs (For availability see N73-26121 17-07)

Propagation through an aerosol of non spherical scatters having transverse stationary statistic distribution is studied by making use of the equivalence to a stratified homogeneous medium with suitable electric characteristics Relationships between the degree of depolarization for linearly and circularly polarized waves, the differential propagation and the physical parameters of the medium are determined Author

N73-26124 Fengler (C), Hamburg (West Germany)
THE PHASE OF A PLANE ELECTROMAGNETIC WAVE TRANSMITTING WIDE SPREAD ATMOSPHERIC DISCONTINUITY
C Fengler *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 8 p refs (For availability see N73-26121 17-07)

For the estimation of multipath progation and phase delay effects the fundamental processes of refraction and reflection at wide-spread atmospheric discontinuities are treated with the aid of an asymmetrical and a symmetrical Epstein profile The reflection against an asymmetrical profile as well as the transition through a non-ionized and an ionized layer of symmetrical profile are considered In particular the phase of the corresponding index of reflection and transmission is evaluated in point of view of frequencies from 10 to 100 GHz and the dimensions of atmospheric inhomogeneities The treatment shows that at the mentioned propagation processes the phase of the incident wave can vary remarkably, it shows herewith a sensitive dependence on the fluctuating parameters of the atmospheric structure Author

N73-26125 Hamburg Univ (West Germany)
PHASE MEASUREMENTS WITH MICROWAVES NEAR THE SEA SURFACE
H W Fruechtenicht *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 9 p refs (For availability see N73-26121 17-07)

Microwave propagation over sea within the [illegible] may be treated by ray tracing The resultant phase of the interference field, which is set up in front of the transmitter, depends on the refractivity N sub 1 on a fixed but arbitrary reference level and on the thickness of the maritime evaporation duct Between the phase and N sub 1 there exists a linear relationship As a function

of duct thickness, however, the phase reveals a discontinuity amounting to integer multiples of 2 pi but at least 2 pi. Therefore, phase measurements near the sea surface may be many valued.
Author

N73-26126* Institute for Telecommunication Sciences, Boulder, Colo. Office of Telecommunications
ATTENUATION AND PHASE DISPERSION IN THE ATMOSPHERE DUE TO THE MICROWAVE SPECTRUM OF OXYGEN
H J Liebe and W M Welch *In* AGARD Telecommun Aspects on Freq. Between 10 and 100 GHz Apr 1973 18 p refs Sponsored in part by NASA and NOAA (For availability see N73-26121 17-07)

Radio wave propagation in the 40- to 140-GHz band through the earth's atmosphere is strongly influenced by the behavior of the O2 microwave spectrum. This behavior causes the transfer function to depend critically upon altitude. The spectroscopic properties of O2 are discussed and reduced to engineering formulas expressing attenuation and phase dispersion rates in terms of frequency and meteorological parameters. The theory is supported on several accounts by reliable spectroscopic measurements. Pressure scanning spectroscopy is used to investigate the O2 microwave spectrum under simulated atmospheric conditions. The application of spectroscopic information to analytical treatments of transfer properties for inhomogeneous slant paths is demonstrated. Attenuation and phase dispersion between 49 and 72 GHz are evaluated for zenith and tangential paths.
Author

N73-26127 Bell Telephone Labs, Inc., Holmdel, N.J.
DEPOLARIZATION OF MICROWAVES IN TRANSMISSION THROUGH RAIN
D C Hogg *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 5 p refs (For availability see N73-26121 17-07)

Relationships are given for depolarization of linearly and circularly polarized microwaves propagating through rain. Computations using a simple model for the rain medium show that depolarization is more significant for circular than for linear polarization.
Author

N73-26128 Bell Telephone Labs., Inc., Holmdel, N.J.
INTRODUCTION TO SESSION 2
D C Hogg *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 2 p refs (For availability see N73-26121 17-07)

The following measurements are required in engineering radio communication systems: (1) Attenuation as a function of path length and time: precipitation, atmospheric gases, spatial variations in refractivity, environment. (2) Bandwidth capability: delays within a band cause by the environment, scattering by precipitation, spatial variation in refractivity. (3) Depolarization: by the environment, precipitation, antennas. (4) Interference: caused by refractivity variations, scattering by precipitation, poor antenna quality, environment, and (5) Phase variations: refractivity changes, precipitation.
Author

N73-26129 Fondazione Ugo Bordoni, Rome (Italy)
CRITERIA AND EXPECTED ACCURACY OF THE MEASUREMENTS ENVISAGED IN THE RESEARCH PROGRAMME UNDER WAY IN ITALY
F Fedi *In* AGARD Telecommun Aspects of Freq Between 10 and 100 GHz Apr 1973 23 p refs (For availability see N73-26121 17-07)

The research program on the free propagation of electromagnetic waves at frequencies higher than 10 GHz is outlined. The aims and criteria governing the approach to the program are discussed and an account is given of the radioelectrical and meteorological measurements to be made and the accuracy which may be expected, on the basis of the foreseeable causes of error and the results of preliminary tests already performed.
Author

N73-26130 Louvain Univ (Belgium) Microwave Lab
EFFECTS DUE TO PRECIPITATION ON HORIZONTAL LINKS AT 12 AND 35 GHZ
A VanderVorst and E Gaudissart *In* AGARD Telecommun. Aspects on Freq. Between 10 and 100 GHz Apr. 1973 6 p refs (For availability see N73-26121 17-07)

Two horizontal line-of-sight links have been installed at 11.7 and 35 GHz in cooperation with meteorological station. A balloon allows measurements to be made in the low atmosphere. The signals are emitted at the top of a tower, reflected back at the top of another building, and received at the location of the emitter. To avoid a coupling between the emitting and receiving antennas, the frequency of the emitted waves is modulated by an amount equal to the intermediate frequency, at a frequency determined by the length of the microwave path. An analog-to-digital conversion allows the data to be computerized: the results at 12 and 35 GHz are autocorrelated, cross-correlated with each other, and cross-correlated with the meteorological parameters. The correlation matrix is used to compute the mean-square regression of the propagation measurements on the meteorological measurements.
Author

N73-26131 Mitre Corp., Bedford, Mass.
PROPAGATION OF 15.6 - 31.2 GHz AND 45 - 90 GHz COHERENT SIGNAL PAIRS
John F Sullivan and Harold M Richardson *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 11 p refs (For availability see N73-26121 17-07)

Two pairs of coherent signals have been transmitted through the atmosphere over a 23.1 km path well clear of terrain features. The lower pair of signals spanned 15.6 GHz and the upper pair spanned 45 GHz of the millimeter spectrum. There is no reason to believe that the entire band from 15 to 90 GHz could not be spanned coherently with appropriate apparatus. However the entire band is not completely useful because of strong absorption near the oxygen absorption lines in the region of 60 GHz and strong temporal and spacially dependent attenuation in the presence of precipitation along the path. It is shown that atmospheric structure imposes commonly minor modulation on mm wave propagation over a limited bandwidth from near zero to a few Hz. this modulation increases with carrier frequency, path length, and intensity of turbulence which in turn varies widely from time to time. Within the limits of the available data, it is concluded that the theory of wave propagation perturbation by turbulent media is valid.
Author

N73-26132 Technical Univ. of Denmark, Lyngby. Lab. of Electromagnetic Theory
IMPROVED DATA FOR PROPAGATION ANALYSIS
Gregers Mogensen *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 4 p refs (For availability see N73-26121 17-07)

In the planning for a new terrestrial propagation experiment it is found that the complex transfer function vs frequency should be measured in a 1.5 GHz wide frequency range. This transfer function would give the most accurate and usable results since it is not directed towards any particular modulation scheme. Since it is not possible to construct a system for measuring the transfer function, a differential gain differential phase measurement system is used. The necessary set of formulas to calculate from the measurement data the RF phase curve deviations from a straight line is established. The formulas are tested by numerical simulations and it is found possible to determine the RF phase curve with an accuracy of 1% relative to the peak peak deviations of the phase curve.
Author

N73-26133 Federal German Post Office, Darmstadt (West Germany). Research Inst. of the Telecommunication Engineering Center
SOME OBSERVATIONS OF SCATTERING FROM RAIN ON A 12 GHz TRANS-HORIZON LINK
N Abel *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 13 p refs (For availability see N73-26121 17-07)

A 12 GHz experimental transhorizon link of 210 km length was operated with an elevated receiving antenna beam which

intersected the transmitting antenna beam over approximately the last quarter of the path. The possible scattering angles ranged around 4 degrees, the half power beam width of both antennas was 1.8 degrees. Rain scatter signals were observed via the main lobe of the receiving antenna without any significant restraint, whereas the permanent, but narrow angle turbulence scatter signals were received via side lobes and therefore, reduced to values most barely above threshold. With the aid of fading character and of weather observations, a statistical distribution of rain scatter transmission loss was isolated from the data. During the strongest rain scatter events, the transmission loss was up to 20 db lower than the average loss for turbulence scatter in this particular configuration. Transmission loss values estimated on the basis of rain gauge data seem to be consistent with the measured ones Author

N73-26134 Norwegian Defence Research Establishment, Kjeller

THE INFLUENCE OF PRECIPITATION AND MULTIPATH FADING ON FREQUENCIES BETWEEN 10 AND 18 GHz

Odd Gutteberg (Norwegian Telecommun Admin Res. Estab., Kjeller) and Anton G Kjelaas *In* AGARD Telecommun Aspects on Freq. Between 10 and 100 GHz Apr 1973 7 p refs (For availability see N73-26121 17-07)

Taken the very short measuring time into consideration, the measured attenuation due to rain fits very well the values obtained from rainfall rate in one point applying the reduction coefficient given by Battesti et al. Multipath fading due to atmospheric stratification (duct) has been observed usually during night with nocturnal radiation. The fading depths observed due to multipath are about 1/3 in db of those caused by rain Author

N73-26135 McGill Univ., Montreal (Quebec) Dept of Meteorology

RAIN ATTENUATION STATISTICS FOR FREQUENCIES ABOVE 10 GHz FROM RAINGAUGE RECORDS

G Drufuca *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 15 p refs (For availability see N73-26121 17-07)

Tipping bucket raingauge records have been used to generate statistics of rain attenuation at 11.2 GHz for a 5-mile microwave link. The knowledge of storm velocity measured by weather radar is used to transform records into profiles of rainfall rate versus distance. These profiles are then properly integrated over a 5-mile length obtaining simulated attenuation values. These are then compiled as probability curves. A comparison between the actual statistics of the link and the simulated statistics shows good agreement Author

N73-26136 Radio and Space Research Station, Slough (England)

THE INFLUENCE OF RAINFALL ON LINE-OF-SIGHT PROPAGATION AT 110 GHz IN SE ENGLAND

D T Llewellyn-Jones and A M Zavody *In* AGARD Telecommun. Aspects on Freq Between 10 and 100 GHz Apr 1973 6 p refs (For availability see N73-26121 17-07)

In the case of millimeter wave propagation through the atmosphere the problem exists of predicting link reliability on the basis of known rainfall data. This requires knowledge of the relationships between rainfall rate at one point and attenuation observed over a given path length. Various methods have been devised to provide more information on these problems at a frequency of 110 GHz. This work involves the use of raingauges and spatially separated propagation links. Some results are described, and it is seen that frequencies as high as 110 GHz have potential practical applications over line-of-sight paths of the order of 3 km length. Predicted reliabilities for some applications can be comparable to those obtained at frequencies near 30 GHz Author

N73-26137 Technical Univ of Denmark, Lyngby Lab of Electromagnetic Theory

EXTRAPOLATION OF PROPAGATION DATA

P Gudmandsen *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 2 p refs (For availability see N73-26121 17-07)

A short description is given of a plan to use field strength recordings on one path for prediction of the performance of another path with somewhat different weather conditions based on weather data recorded simultaneously. The influence of rain on the performance of communication links at frequencies in the range 10 - 18 GHz is considered Author

N73-26138 Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France)

EXPERIMENTAL METHOD OF MEASURING PROPAGATION ATTENUATION OF RAIN [METHODE EXPERIMENTALE DE MESURE DE L'AFFAIBLISSEMENT DE PROPAGATION DU A LA PLUIE]

P. Misme, L. Boithias, and J. Battesti *In* AGARD Telecommun. Aspects on Freq Between 10 and 100 GHz Apr 1973 6 p ref In FRENCH (For availability see N73-26121 17-07)

After having given a theoretical definition of equivalent precipitation intensity, it is pointed out how this quantity may be calculated experimentally with the help of propagation results. The value of a reduction coefficient, function of the length of a connection and percentage of time are described. Consequently, with the help of experimental results, a method is developed that permits calculation of absorption as a product of rain for a percentage of any time and for all frequencies less than frequencies in the vicinity of 30 GHz and distances less than about 20 kilometers Author

N73-26139 Communications Research Centre, Ottawa (Ontario)

AMPLITUDE FADING OF SATELLITE COMMUNICATIONS SIGNALS AT SHF

K S McCormick, R L Olsen, and L A Maynard *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 8 p refs (For availability see N73-26121 17-07)

For SHF satellite communications systems designed to operate at elevation angles less than several degrees, allowance must be made for fluctuations in the signal level caused by variations in the refractive structure of the troposphere. As part of a program to investigate these effects, the signals from satellite beacons at 7.3 GHz have been monitored during several periods over the last five years. The results show that in the summer months, the fading is greater than 10 db for 0.1% of the time at elevation angles below three degrees, while, for the winter months, fades greater than 6 db occur under the same conditions. A limited series of observations at resolute (latitude 75 N) show that in the Arctic, the fading in the summer is similar to that which occurs in Ottawa in the winter Author

N73-26140 Radio and Space Research Station, Slough (England)

SLANT PATH ATTENUATION AT FREQUENCIES ABOVE 10 GHz

P G Davies *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 11 p refs (For availability see N73-26121 17-07)

Results obtained from solar tracking radiometer measurements made at 19 GHz and at 37 GHz have been studied to give data on attenuation (primarily caused by rain) on paths through the troposphere. Such information is required in the planning and operation of microwave links to and from satellites. The results are presented in statistical form as cumulative distributions of the percentage of the observation time for which the attenuation exceeds various values. Analysis of individual fades exceeding 5 and 10 db at both 19 and 37 GHz has also been carried out and the results are presented as histograms showing the number of fades as a function of fade duration Author

N73-26141 Texas Univ., Austin Electrical Engineering Research Lab

STATISTICS ON EARTH SATELLITE ATTENUATION AT TWO TEXAS LOCATIONS

A W Straiton, David N Pate and Bob M Fannin *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 9 p refs (For availability see N73-26121 17-07)

Propagation experiments using the 15.3 GHz transmitter on the ATS-5 satellite as a signal source are reported. Signal strength

data were recorded at two locations at Austin in central Texas for twenty months and at Mount Locke in far west Texas for five weeks. The elevation angle in each case was near 54 deg. It is concluded that for high elevation angles severe attenuation is almost always associated with thunderstorms. Curves of percentage of time versus path attenuation for an average year are given for both sites. The height of the top of the thunderstorm cloud was found to be a fairly good single indicator of the intensity and duration of fades Author

N73-26142 Communications Research Centre, Ottawa (Ontario). Dept. of Communications
COMPARISON OF DIRECT AND INDIRECT MEASUREMENTS OF PRECIPITATION ATTENUATION AT 15.3 GHz
J. I. Strickland *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 8 p refs (For availability see N73-26121 17-07)
The signal strength received at 15.3 GHz from the ATS-5 satellite was measured using a 9 metre antenna. The receiving antenna is also connected as a total-power radiometer, providing simultaneous measurements of the sky noise temperature at 15.3 CHz with an antenna beamwidth of 0.15 degrees. Attenuations, calculated from the measured sky temperatures, show very good agreement with the directly measured attenuations Author

N73-26143 Aerospace Corp., El Segundo, Calif. Electronics Research Lab
SPACE COMMUNICATIONS SYSTEMS CONSIDERATIONS AT 94 GHz
H. J. Wintroub and L. A. Hoffman *In* AGARD Telecommun Aspects on Freq Between 10 and 100 GHz Apr 1973 17 p refs (For availability see N73-26121 17-07)
The effects of atmospheric physical phenomena in determining satellite-ground radio link performance are considered. Experimental data are presented as a basis for the determination of link margins and tradeoffs between communication capacity and outage because of rain-induced attenuation or high atmospheric turbulence. State-of-the-art and predicted performance of future millimeter wave components are considered in formulating the spacecraft and ground terminal systems. Included are a beam swinging experiment using a precision controlled 4.57-m antenna to obtain data on wavefront tilt fluctuations, time histories of amplitude scintillation for 0.15-, 0.61-, and 4.57-m apertures, and statistical data on water vapor attenuation Author

N73-32053# Advisory Group for Aerospace Research and Development, Paris (France)
SPREAD SPECTRUM COMMUNICATIONS
Jul 1973 196 p refs
(AGARD-LS-58) Avail NTIS HC $12.00
The theory, implementation, and application of state-of-the-art spread spectrum techniques to advanced communication systems are discussed. The fundamental and theoretical aspects of communication theory, digital communications theory, and spread spectrum communications are reported. The practical aspects of spread spectrum techniques, particularly the performance and synchronization considerations, and several state-of-the-art applications are described. Predictions of future communication systems with spread spectrum methodology are included. For individual titles, see N73-32054 through N73-32058

N73-32054 Rensselaer Polytechnic Inst., Troy, N.Y. Systems Engineering Div
SOME FUNDAMENTAL NOTIONS OF COMMUNICATION THEORY
Lester A. Gerhardt *In* AGARD Spread Spectrum Commun Jul 1973 24 p refs (For availability see N73-32053 23-07)
The basic concepts of communications theory to include the transmission of continuous signals and the use of discrete time signals are presented. A numerical analysis of communication signals, the spectral characteristics of the signals and a probabilistic description of the signals are developed. The basic types of modulation, to include amplitude, pulse, and angle modulation and related forms are examined. The characteristics of the signal receiver with emphasis on signal detection and filtering are described. The effect of the sampling theorem on the spectral characteristics of signals is analyzed. The problems of quantization are outlined for discrete time and discrete amplitude signals Author

N73-32055 Manchester Univ (England) Dept of Electrical Engineering and Electronics
DIGITAL COMMUNICATIONS THEORY
Geoffrey F. Gott *In* AGARD Spread Spectrum Commun Jul 1973 16 p refs (For availability see N73-32053 23-07)
The characteristics of digital communication systems and the processing of bandpass digital signals are discussed. The modulation and detection of frequency shift keyed and phase shift keyed signals are considered in binary and multilevel form. Emphasis is placed on radio frequency data transmission where spread spectrum techniques have application. Methods of providing protection against the effects of signal fading due to multipath propagation are analyzed. Elementary forward error correcting codes of the type used in radio frequency channels are examined Author

N73-32056 Signals Research and Development Establishment, Christchurch (England)
INTRODUCTION TO SPREAD SPECTRUM TECHNIQUES
R. L. Harris *In* AGARD Spread Spectrum Commun Jul 1973 21 p (For availability see N73-32053 23-07)
The basic principles and operation of a spread spectrum communication system are discussed. Spectrum spreading by means of direct modulation is considered in detail and compared with an alternative method using frequency hopping. A key feature of any spread spectrum system is the pseudo random sequence and the basic properties and generation of such sequences are discussed. Finally the performance of a typical satellite communication system using spread spectrum as a multiple access method is calculated Author

N73-32057 Communications Research Centre, Ottawa (Ontario)
PERFORMANCE AND SYNCHRONIZATION CONSIDERATIONS
N. G. Davies *In* AGARD Spread Spectrum Commun Jul 1973 24 p refs (For availability see N73-32053 23-07)
The performance of spread spectrum systems in the presence of various forms of channel noise is analyzed. The synchronization aspects of spread spectrum systems are examined. The subjects discussed are (1) acquisition by search in the time and frequency domains, (2) the use of preambles and special sequences for synchronization and (3) the establishment of synchronization detection and tracking criteria Author

N73-32058 Magnavox Research Labs, Torrance, Calif
SPREAD SPECTRUM APPLICATIONS AND STATE OF THE ART EQUIPMENTS
Charles R. Cahn *In* AGARD Spread Spectrum Commun Jul 1973 111 p refs (For availability see N73-32053 23-07)
The applications of spread spectrum communications to avionics systems are described. The following topics are discussed (1) multiple access capabilities, (2) interference rejection, (3) identification characteristics, and (4) distance measuring and position location capabilities. The characteristics and uses of current spread spectrum equipment are reported. Recent technology discoveries, such as acoustic surface wave and charge coupled devices are explained Author

N74-11954# Advisory Group for Aerospace Research and Development, Paris (France)
DETERMINATION AND USE OF RADAR SCATTERING CHARACTERISTICS
Sep 1973 171 p refs Conf held at Bolkesjoe, Norway, 11-12 Oct 1973, London, 15-16 Oct 1973, The Hague, 18-19 Oct 1973
(AGARD-LS-59) Avail NTIS HC $10.75

Radar echoes and radar cross sections are reviewed for different classes of targets main parameters affecting backscatter signal are analyzed For individual titles, see N74-11955 through N74-11967.

N74-11955 EMI Electronics Ltd , Wells (England)
INTRODUCTORY LECTURE: TARGET SCATTERING CHARACTERISTICS OF IMPORTANCE TO RADARS
L R Cram *In* AGARD Determination and Use of Radar Scattering Characteristics Sep 1973 4 p (For availability see N74-11954 03-07)

Scattering characteristics of interest include the Doppler content, the range noise and the angular glint as well as the radar cross section (RCS), or radar echoing area (REA) A definition is given of these parameters (RCS or REA) and the physical reasons for variations around a target are discussed Both amplitude and rate of change significantly affect radar performance Reciprocally, the value of the radar echoing area can itself be affected by the radar paramaters such as modulation type, frequency and polarization Target glint will affect the accuracy of directional information provided by the radar The rates of change and frequencies of change of glint are also important Radar parameters and the glint data interact with each other in that polarization characteristics of the radar affect the glint and its frequencies while the significance of glint frequencies depends on radar servo rates, etc Targets which are of interest include land, sea and airborne vehicles Sea and land reflections represent either clutter or targets in their own right Birds represent hazards to aircraft so their radar scattering is also of interest Author

N74-11956 Ohio State Univ , Columbus ElectroScience Lab
COMPUTATIONAL AND ANALYTICAL DETERMINATION OF RCS
Edward M Kennaugh *In* AGARD Determination and Use of Radar Scattering Characteristics Sep 1973 9 p refs (For availability see N74-11954 03-07)

Improvements in computational techniques for calculation of RCS now permit wider ranges of objects to be analyzed The lecture reviews the state of the art at present, with a description of two basic approaches. The point matching or wire grid model utilizes a matrix description of a three dimensional shape and proceeds to calculate RCS through solution of a large order system of linear equations The asymptotic or quasi optical solution identifies key contributions to RCS which may be given simple mathematical description and summed automatically with proper account of phasing as a function of attitude The limitations and virtues of each method are described, and the possibility of combining both computational methods is explored Illustrative examples are presented, and the importance of this tool as an adjunct to experimental RCS studies is discussed Author

N74-11957 Test Group (6585th), Holloman AFB, N Mex Radar Target Scatter Facility
STATIC FULL SCALE MEASUREMENTS OF RCS
Carroll R Griffin, Jr *In* AGARD Determination and Use of Radar Scattering Characteristics Sep 1973 11 p (For availability see N74-11954 03-07)

A number of techniques for the measurement of radar cross section are discussed and compared A description of the theory of operations of a ground plane range is provided Some considerations for use and some of the advantages of the ground plane method result from the theory A description of the equipment and methods for obtaining RCS data is followed by a description of special measurement systems available Finally, a brief description of the functional organization required in the operation of an RCS measurement site is provided Author

N74-11958 Air Force Avionics Lab , Wright-Patterson AFB, Ohio Observables Group
DYNAMIC FULL SCALE MEASUREMENT OF RCS
William F Bahret *In* AGARD Determination and Use of Radar Scattering Characteristics Sep 1973 16 p refs (For availability see N74-11954 03-07)

Trade offs and technical considerations in dynamic measurements of radar cross section are discussed to establish requirements for instrumentation and techniques used for such measurements Primary emphasis is given to aircraft targets although most of the discussion applies to sea or land based targets as well Block diagrams of practical systems for measuring amplitude and angular scintillation are presented and discussed Typical output data are related to the primary user requirements Author

N74-11959 EMI Electronics Ltd , Wells (England)
MODELLING METHODS OF DETERMINING RADAR ECHO CHARACTERISTICS
L A Cram *In* AGARD Determination and Use of Radar Scattering Characteristics Sep 1973 7 p (For availability see N74-11954 03-07)

Optical modelling is now rarely used but ultrasonic modelling is far more effective A well instrumented facility for ultrasonic modelling is described which operates in water with wavelength scaling from 1/10 to 1/40 Speedy operation and good range discrimination are particularly advantageous Radio scale modelling has additional advantages and a radio scale modelling facility incorporating five different measuring equipments is described Mutual interference is avoided by range gating the radars Scaling is from 1/1 to 1/100 and many different radars operate from 1 GHz to 100 GHz Targets of metal coated wood are suspended by nylon strings Two general purpose equipments permit flexible choice of radar system, aerial type, wavelength and polarization Other systems are specialized for investigating the end course of a missile radar, the reflections from sea waves and the effects of target glint on radar aiming errors A radar system assessment team with computers completes the radio modelling facility Author

N74-11960 EMI Electronics Ltd , Wells (England)
TARGET CHARACTERISTICS
S C Woolcock *In* AGARD Determination and Use of Radar Scattering Characteristics Sep 1973 18 p refs (For availability see N74-11954 03-07)

A knowledge of the radar scattering properties of complex targets is a necessary requirement for the detailed study of modern radar systems The use of computers for such studies requires that these properties shall be described in compact form By making radar measurements of high quality scaled models a better understanding of target reflectivity is being achieved The dependence of the received signal on the frequency and polarization of the incident field as well as on the characteristics of the radar system is described Reflections from simple shapes are discussed to show how the radar cross section can be computed by geometric optics, physical optics and by consideration of travelling wave echoes The sources of radar reflection for an aircraft and for a missile shape are next discussed These were determined by measurement There follows an introduction to the concept of angular glint Glint properties of a complex target are described and associated with the perturbations on phase fronts Features of glint are highlighted, in particular the wander of the mean glint centre with the target outline Finally an example is shown of Doppler spectra obtained from an aircraft Spectral lines associated with moving parts are usually present In this instance several frequency components have arisen which can be associated with the rotating turbines of engines Author

N74-11961 Royal Radar Establishment, Malvern (England)
RADAR ECHOING AREAS OF FLYING ANIMALS
E W Houston *In* AGARD Determination and Use of Radar Scattering Characteristics Sep 1973 11 p refs (For availability see N74-11954 03-07)

The echo signal from a flying animal consists of at least two components an average or mean component and an amplitude modulated component The mean component is proportional to the slow variations in echoing area, resulting from long term variations of the animal's aspect as it flies past the radar The modulation component follows the rapid variations generated by wing flapping or by transient fluctuations in echoing area produced, for example by head movements The periodic wingbeat modulation of the echo signal from even a small bird is distinctive and makes it easy to separate this form of target out from echoes By selective measurements on flying animals

under laboratory conditions the task of specifying radar echoing areas can be reduced when these static cross sections are compared with dynamic echoing areas measured on animals in flight. Author

N74-11962 Royal Radar Establishment, Malvern (England)
RADAR SEA CLUTTER
Geoffrey Bishop *In* AGARD Determination and Use of Radar Scattering Characteristics Sep. 1973 21 p (For availability see N74-11954 03-07)

Radar sea clutter studies have been made based on a series of trails, in which X-band non-coherent radar measurements have been taken from a cliff top site in Cornwall, England. Horizontal, vertical and circular polarizations were transmitted using pulse lengths of 70 nanosec and 270 nanosec with an antenna beamwidth of 0.6. Horizontal, vertical or both hands of circular polarization were received. Amplitude distribution curves show the effects of change in sea state, polarization and pulse length on the cross sectional echoing area characteristics of sea clutter and moored buoy targets. Cross polarization effects have been studied. Autocorrelation analyses of the recorded radar returns show clutter decorrelation times varying from 5 milliseconds to several seconds. Author

N74-11963 Forschungsinstitut fuer Funk und Mathematik, Werthoven (West Germany).
THE USE OF TARGET AND CLUTTER DATA FOR DIFFERENT METHODS OF DISCRIMINATION BETWEEN TARGETS AND UNWANTED CLUTTER
Karl VonSchlachta *In* AGARD Determination and Use of Radar Scattering Characteristics Sep 1973 21 p refs (For availability see N74-11954 03-07)

The signal processing procedures adopted in surveillance radars for discriminating target and clutter are based on results of statistical decision theory. The practical implementation is discussed with reference to two groups of radar and the influence of target and clutter characteristics are pointed out. A first group comprises the processing of incoherent video signals. The examples are the sequential detection device, the Scan to Scan MTI and procedures for fast switching between normal and MTI video signal. A second group deals with the processing of coherent radar signals. The Doppler information of moving targets is used for the discrimination between targets and unwanted clutter. A modern device applying the likelihood ratio test and using Doppler filters in the time domain is described. Further investigations are made for suppression of moving clutter by adaptive filtering. Author

N74-11964 Test Group (6585th), Holloman AFB, N Mex Radar Target Scatter Facility.
PRESENTATION AND STORAGE OF RADAR CROSS-SECTION DATA
Carroll R. Griffin, Jr *In* AGARD Determination and Use of Radar Scattering Characteristics Sep. 1973 24 p (For availability see N74-11954 03-07)

The data required to be taken in conjunction with the measurement of radar cross sections are divided into two categories, that associated with the target orientation or aspect and that associated with the radar measurement parameters. Several types of presentation are used, and various types of records of the data are available, both analog and digital. The standardization of data formats and conventions for target orientations are important objectives which should be established for the benefit of users of RCS data. Author

N74-11965 EMI Electronics Ltd., Wells (England).
USE OF RADIO MODELLING DATA
S. C. Woolcock *In* AGARD Determination and Use of Radar Scattering Characteristics Sep. 1973 13 p refs (For availability see N74-11954 03-07)

The U.K. radio modelling facility has permitted the amassing of much data concerning reflections from a wide variety of radar reflecting objects at many different frequencies and at all possible polarization configurations. The data must be reduced by a method which does not remove details of the scattering signal to which the radar system is sensitive. Three methods are in use: (1) Statistical summaries such as cumulative probability, spectral distribution, autocorrelation function or mean value and standard deviation, (2) look-up table (no data reduction) using computer storage data on echo characteristics of targets; and (3) multiple source mathematical models that represent a target by a number of elementary sources, each of defined strength, polar diagram and position. A radar analysis example is given where a simple computer program determines the performance of a sequential lobing radar in locating a shell whose polar echo characteristics are fed directly from a recording of the radio range data. Author

N74-11966 Air Force Avionics Lab., Wright-Patterson AFB, Ohio. Observables Group.
THE USE OF RCS DATA
William F. Bahret *In* AGARD Determination and Use of Radar Scattering Characteristics Sep. 1973 10 p refs (For availability see N74-11954 03-07)

Data requirements and limitations are emphasized that are associated with systems analysis involving radar cross section, rather than the mechanics of any actual analysis. Treated separately as increasingly sophisticated levels of target characterization are far zone, near zone, and glint data. Typical applications and practical requirements for these applications are discussed to define adequate methods for obtaining and presenting RCS data. The general theme is that applying RCS data is rather straightforward provided that truly pertinent and accurate data are available in suitable form. On the other hand, to settle for less in the way of RCS data is to gamble an expensive system design to save the relatively small investment for obtaining proper data. Author

N74-11967 EMI Electronics Ltd., Wells (England).
STATE OF THE ART AND FUTURE PROSPECTS
L. A. Cram *In* AGARD Determination and Use of Radar Scattering Characteristics Sep 1973 [illegible] p (For availability see N74-11954 03-07)

The state of the art regarding radar scattering characteristics and their acquisition and use is summarized. It is indicated how a choice may be made among the various methods for finding and for using radar cross section data to assess radar performance. Those are many methods of collecting radar data. Each has its different disadvantages but when the various methods are used with care and within their limitations they give consistent and comparable results with one another. Hence bearing in mind the appreciable costs it is important to choose an optimum use of the various methods. This optimum will often mean some use of all of the techniques. Each radar systems investigation must be examined to determine the particular optimum procedure for finding the echo data needed for that study. Author

N74-13846# Advisory Group for Aerospace Research and Development, Paris (France).
PROPAGATION EFFECTS OF FREQUENCY SHARING
I. Ranzi, ed (Ist. Super. P T Viale Trastevere) Sep 1973 307 p In ENGLISH, partly in FRENCH Presented at the Specialists Meeting of the Electromagnetic Wave Propagation Panel, Rome, 7-11 May 1973
(AGARD-CP-127) Avail NTIS HC $17.50

Problems related to the propagation effects which may influence the feasibility of frequency sharing among various telecommunication services are considered. For individual titles see N74-13847 through N74-13871.

N74-13847 Radio and Space Research Station, Slough (England).
INTRODUCTORY SURVEY TO SESSION 1 PROPAGATION OVER IRREGULAR TERRAIN
R. W. Meadows *In* AGARD Propagation Effects of Freq Sharing Sep 1973 2 p (For availability see N74-13846 05-07)

A survey is presented on the general problem of predicting wave propagation loss over irregular terrain and the production of unwanted high signal levels at a distance. Mathematical predictions of terrain screening effects and field strength for a ground path of a given profile are considered in suitable siting selections for communication terminals. G.G.

N74-13848 British Broadcasting Corp, Kingswood (England)
THE PROPAGATION OF ELECTROMAGNETIC WAVES OVER IRREGULAR TERRAIN
R W King and H Page *In* AGARD Propagation Effects of Freq Sharing Sep 1973 20 p refs Prepared in cooperation with Imp Coll of Sci and Technol (For availability see N74-13846 05-07)

A method is proposed for calculating the field strength of radio frequency signals propagated over irregular terrain, a typical application is to estimate the diffraction loss in the shadow of hills, or similar obstacles, for terrestrial transmitters working on frequencies between 50 and 1000 MHz Approximations are made in the theoretical treatment in order to make the method sufficiently simple to be used in the planning of practical systems The ground irregularities are regarded as approximating to one or other of a set of standard obstacles, the extent of the local irregularity which determines the effective obstacle shape is determined, thus enabling irregular ground to be approximated to a series of the standardized obstacles The diffraction loss is deduced first for single obstacles and then for multiple obstacles, the obstacles are assumed to be smooth, but the effect of roughness is discussed The theoretical results are compared with measurements using small scale models and also with practical field surveys Author

N74-13849 Centre National d Etudes des Telecommunications, Issy-les-Moulineaux (France)
ROLE OF ATMOSPHERIC DUCTS IN THE PHENOMENA OF INTERFERENCE OVER LARGE DISTANCES [ROLE DES CONDUITS ATMOSPHERIQUES DANS LES PHENOMENES DE BROUILLAGE A GRANDE DISTANCE]
P Misme *In* AGARD Propagation Effects of Freq Sharing Sep 1973 12 p refs In FRENCH (For availability see N74-13846 05-07)

A theory was developed to serve as a guide to propagation interference caused by atmospheric ducts Data cover leakage coefficients, propagation curves and the influence of terrain and water on propagation Transl by E H W

N74-13850 Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France)
EFFECT OF TERRAIN SCREENING ON THE DIFFERENT MECHANISMS OF PROPAGATION [EFFET D'ECRAN DU TERRAIN POUR LES DIFFERENTS MECANISMES DE PROPAGATION]
L Boithias *In* AGARD Propagation Effects of Freq Sharing Sep 1973 9 p refs In FRENCH (For availability see N74-13846 05-07)

The influence of various terrain screening techniques on propagation mechanisms is investigated Data are included on diffraction by ridges, spherical diffraction tropospheric diffusion, precipitation diffusion refraction and reflection Particular attention was given to the role played by local relief Transl by E H W

N74-13851 Imperial Coll of Science and Technology London (England)
RADIO WAVE DIFFRACTION DUE TO A MOUNTAIN OF VOLCANIC ORIGIN
W G Burrows and J D Ridler *In* AGARD Propagation Effects of Freq Sharing Sep 1973 26 p refs (For availability see N74-13846 05-07)

A simple modelling technique is employed to examine the field distribution in the shadow of a mountain obstacle which is approximately conical in overall shape and typical of one of volcanic origin The experimental procedure includes measurements of the field distributions in the shadows of a right circular cone representing the ideal mountain shape and a right circular cone whose surface contours are modified to give an approximate scale model representation of an actual mountain Distributions are also obtained for the field intensities in the shadow regions of these obstacles when the air over their upper surfaces supports a temperature gradient which is subjected to the additional influence of an air stream Results are given to indicate by comparison with those obtained for a simple knife edge representing the mountain, the magnitudes of the errors that might arise in the calculation of the obstacle loss or gain for a radio path when no account is taken of the obstacle shape and the state of the atmospheric medium above its surface Author

N74-13852 Research Inst of National Defence Stockholm (Sweden)
VARIATIONS IN DIFFRACTION LOSS DUE TO TROPOSPHERIC EFFECTS AT FREQUENCIES BETWEEN 180 MHz AND 10 GHz IN HILLY TERRAIN
Ake Blomquist, Folke Eklund, and Lennart Nilsson *In* AGARD Propagation Effects of Freq Sharing Sep 1973 13 p refs (For availability see N74-13846 05-07)

The variations in time of the diffraction loss at the frequencies 180, 2300 and 9350 MHz have been studied over a 30 km path in irregular terrain typical for central Sweden during a period of about 3 years In addition to these measurements, short term field strength recordings have been carried out at 44 66, 88 and 1000 MHz The angular distance of the path was 0 38 deg The diffraction loss over the path was normally quite constant at the frequencies studied The stable signal had however, a superimposed component of very small amplitude with rapid fading probably due to turbulent scatter Mainly at night during summer it occured that the screening effect was considerably reduced due to propagation disturbances caused by layered tropospheric structures Two different types of signal can then be distinguished rapid amplitude variations of irregular character with a somewhat higher average level compared to the stable signal mentioned above, and rather slow amplitude variations with deep fading minima of regular character and with a much higher average level than the stable one Statistics of the variations in diffraction loss are presented and possible propagation mechanisms causing the variations are discussed Author

N74-13853 Centro Radioelettrico Sperimentale G Marconi, Rome (Italy)
TROPOSPHERIC INFLUENCE ON THE SCREENING EFFECT DUE TO A MOUNTAIN RIDGE, ON 3 GHz
I Ranzi and P Giorgi *In* AGARD Propagation Effects of Freq Sharing Sep 1973 3 p (For availability see N74-13846 05-07)

During one year, measurements have been carried out of the basic propagation loss at 3 04 GHz in a 56 2 km path, comprising a mountain flat top of 933 m of height The annual median value of the basic propagation loss resulted to be 220 7 db, the median loss due to obstacle was 83 7 db, that is more than 45 db higher than the loss due to a knife edge obstacle The statistical analysis of the received signal showed the presence of a Rayleigh component and of a slow fading component, the monthly median value of the last component was about 10 db lower than the Rayleigh component on January and 3 db lower on June As the monthly median signal amplitude increased by about 14 db from January to June, it seems that an important contribution derived from partial reflections from relatively stable layers above the mountain top Author

N74-13854 Computer Sciences Corp, Falls Church Va
PRECIPITATION MODELS FROM RADAR AND RAINFALL DATA
Frederick J Altman *In* AGARD Propagation Effects of Freq Sharing Sep 1973 18 p refs (For availability see N74-13846 05-07)

To guide estimates of attenuation and scattering of radio waves, a model for spatial distributions of reflectivity in storm cells has been fitted to digitized radar data The model assumes ellipses for contours of constant reflectivity factor Z with constant orientation and eccentricity within a horizontal cell cross section at a given time and evaluation The centers of the ellipses are assumed uniformly spaced on a straight line with areas linearly related to log Z except for cell tops and bottoms, and for splitting, the cross sections were similar at different heights, especially for the highest reflectivities In an attempt to relate reflectivity aloft to surface rainfall, similar radar data and hourly rainfall from 30 stations within a circular area about 200 km in radius were used to study precipitation distributions in time and space Both types of data were found to provide similar distributions, with useful correlations among several parameters Author

N74-13855 Deutsche Bundespost, Darmstadt (West Germany)
MEASUREMENTS OF PRECIPITATION SCATTER AT 11.6 GHz
F Dintelmann and F Ruecker *In* AGARD Propagation Effects of Freq Sharing Sep 1973 6 p refs (For availability see N74-13846 05-07)

A bistatical experimental study of precipitation scatter at 11.6 GHz is proposed that uses simultaneously steerable transmitting and receiving antennas separated by a large area. This allows for scatter observations on rainshowers crossing the radio link and to determine the structure and dynamics of rain cells G G

N74-13856 Office of Telecommunications, Boulder, Colo
ESTIMATING ATTENUATION, SCINTILLATION, AND SCATTERING DUE TO RAINFALL FOR SATELLITE/GROUND SYSTEMS
H T Dougherty and E J Dutton *In* AGARD Propagation Effects of Freq Sharing Sep 1973 13 p refs (For availability see N74-13846 05-07)

A state-of-the-art engineering model is described for estimating the expected performance degradation of satellite-to-ground microwave systems because of atmospheric gases, clouds, and rain. The model incorporates an allowance for the spatial structure of atmospheric gases, clouds and rain as well as local and regional rainfall statistics. The estimates are in terms of attenuation and scintillation as well as the volume reflectivity which contributes to co-channel interference. Composite predictions are given for 15 GHz, as representative of microwave signals for small percentages of an average year. This prediction is a function of location and the angle-of-arrival at ground stations on the central east coast of the U S A Author

N74-13857 Technische Hogeschool, Eindhoven (Netherlands)
INTRODUCTORY SURVEY TO SESSION 3 CONTROL OF ANTENNAE SIDE LOBES
B VanDijl *In* AGARD Propagation Effects of Freq Sharing Sep 1973 9 p refs (For availability see N74-13846 05-07)

After a short discussion of the importance of side lobes for communication networks and of their physical background, the emphasis is laid on the development of insight in the possibilities of influencing near angle side lobes. The effect of blocking of the aperture by obstructions is discussed in general terms and an estimate is made of the magnitude of the blocking effect Author

N74-13858 Technische Hogeschool, Eindhoven (Netherlands)
SOME ASPECTS OF NEAR AND FAR ANGLE SIDELOBES IN DOUBLE-REFLECTOR ANTENNAS
J Dijk and E J Maanders *In* AGARD Propagation Effects of Freq Sharing Sep 1973 16 p refs (For availability see N74-13846 05-07)

Analysis and synthesis of the directive gain pattern of reflector antennas, especially Cassegrain antennas are considered. After a short introduction into the geometry of classical and shaped Cassegrain antennas, scalar aperture theory is used in a method to calculate the main lobe and near angle sidelobes of a blocked aperture. Scalar aperture theory is also used to calculate the sidelobes of mismatched shaped Cassegrain antennas. The second part of the paper deals with far angle sidelobes. An example of Kirchhoff integration is shown and finally it is demonstrated that by shaping main and subreflector power scattered by subreflector and supports may be transported in the correct phase to the aperture, decreasing far angle scattering Author

N74-13859 Societa Italiana per l'Esercizio Telefonico, Rome (Italy)
THE RADIATION DIAGRAMS OF ANTENNAS USED IN TERRESTRIAL MICROWAVE LINE-OF-SIGHT SYSTEMS
C Colavito and G Masone *In* AGARD Propagation Effects of Freq Sharing Sep 1973 8 p refs (For availability see N74-13846 05-07)

Measurements carried out on parabolic disk antennas used in terrestrial microwave line of sight relay systems are reported. These systems are allocated in the 7 GHz frequency band which is shared between terrestrial and satellite fixed services. The measurements have been performed in a field where the free space propagation conditions were approximated, as well as in the real installation conditions. In the two above mentioned situations, the smoothed envelopes of the radiation diagrams have been obtained for different types of antennas. Some conclusive remarks are made concerning the characteristics of the terrestrial radio relay antennas to be considered in the interference analyses Author

N74-13860 Louvain Univ (Belgium)
SYNTHESIS OF APERTURE DISTRIBUTIONS FOR OPTIMUM GAIN WITH NOISE AND INTERFERENCE REJECTION
M Safak and P Delogne *In* AGARD Propagation Effects of Freq Sharing Sep 1973 12 p refs (For availability see N74-13846 05-07)

Synthesis of the aperture distributions yielding the best rejection of noise or interfering sources located in a given region of the radiation pattern is examined. Previous methods are reviewed. It is shown that they are not always optimum or require too much computer time, or yield too complicated distributions for practical purposes. The proposed method permits the optimization of the gain-to-temperature ratio for an arbitrary distribution of noise and interfering sources, it avoids superdirectivity and even unnecessary sophistication of the distribution. Results are presented for linear and circular apertures with symmetrical distributions Author

N74-13861 Fondazione Ugo Bordoni, Rome (Italy)
INTRODUCTORY SURVEY TO SESSION 4. PROPAGATION DATA FOR INTERFERENCE PROBABILITY DETERMINATIONS
F Fedi *In* AGARD Propagation Effects of Freq Sharing Sep 1973 5 p refs (For availability see N74-13846 05-07)

Varied aspects of tropospheric propagation and interference probability calculation methods are considered for a wide range of frequencies. Wave scattering, reflecting and ducting phenomena are studied as well as attenuation due to the atmosphere and to precipitations both for terrestrial and satellite radio links G G

N74-13862 SIGMA Association, Hamburg (West Germany)
DUCTING PROPERTIES OF ELEVATED LAYERS
C Fengler *In* AGARD Propagation Effects of Freq Sharing Sep 1963 9 p refs (For availability see N74-13846 05-07)

Field strength observed at VHF and UHF transhorizon paths exceeds considerably the average value in 10% of time. These 10% values are due to the influence of elevated layers if ground based layers are absent. In the referred observations at individual paths the obvious explanation by reflection processes fails because of ray geometry. Ducting mechanisms have to be assumed. The possibilities of ducting are generally considered in point of view of ray theory, wave optics, and path geometry for various tropospheric profiles Author

N74-13863 Research Inst of National Defence, Stockholm (Sweden)
THE OCCURRENCE OF VERY HIGH FIELD STRENGTHS AT BEYOND THE HORIZON PROPAGATION OVER SEA IN THE FREQUENCY RANGE 60 - 5000 MHz
Sture Wickerts and Lennart Nilsson *In* AGARD Propagation Effects of Freq Sharing Sep 1973 15 p refs (For availability see N74-13846 05-07)

The occurrence of enhanced fields has been studied over a sea path of 160 km at the frequencies 170 MHz, 460 MHz and 5000 MHz. For short periods also 60 MHz was used. Long term measurements of field strength have been performed since 1968, which includes some period of meteorological measurement. For these measurements an airborne refractometer, captive balloon sondes and an acoustic sounder were used. The received signals can be classified by the following three types: Standard atmosphere signal (tropospheric scatter signal), unstable high signal caused by reflection in elevated tropospheric layers, and stable high signal caused by ducting. The fact that the signals at different frequencies are only occasionally correlated indicates that the propagation is governed by different mechanisms in

different parts of the frequency spectrum A case study of propagation under various tropospheric conditions and the long term statistics of the different signal types are given Author

N74-13864 Communications Research Centre Ottawa (Ontario)

INTERFERENCE MEASUREMENTS AT 15 7 GHz OVER A LONG TRANSHORIZON PATH

R L Olsen and U H W Lammers *In* AGARD Propagation Effects of Freq Sharing Sep 1973 15 p refs Prepared in cooperation with AFCRL, H G Hanscom Field, Mass (For availability see N74-13846 05-07)

Experiments are being carried out to obtain transmission loss statistics for 500 km overland path at 15 7 GHz The interference situation simulated is that of a terrestrial transmitter interfering into the earth terminal receiver of a space communications system along the great circle path between them or at off path angles close to the great circle azimuth The initial results of measurements over a six month period indicate that, for this path, the empirical method underestimates the transmission loss not exceeded for small percentages of the time by an amount which increases with the elevation angle of the earth station antenna Additional analysis is also being carried out to determine the relative occurrences of turbulent scattering, hydrometer scatter (including cloud scatter), and ducting, and to separate the data accordingly Author

N74-13865 GEC-Marconi Electronics Ltd , Chelmsford (England)

TROPOSCATTER PROPAGATION IN AN EQUATORIAL CLIMATE

R Larson *In* AGARD Propagation Effects of Freq Sharing Sep 1973 9 p refs Sponsored by the Min of Defence (For availability see N74-13846 05-07)

A troposcatter link between Singapore and Penang was operated for almost two years During this time continuous analogue recordings of received signal strength were made, and meteorological measurements were also made at both ends of the link The radiometeorology proved to be very stable and was an excellent example of equatorial type climate The measured median signal level was very close to the predicted value and also the hourly median signal levels followed a log-normal distribution with great fidelity, even to extreme percentage levels, both high and low Consideration of the available data led to the conclusion that there was no evidence of any ducting at all a pure scatter signal being received throughout Fast fading records indicated that even at the highest signal levels a Rayleigh fading signal was present and the log-normal and Rayleigh distributions have been combined to produce an overall distribution of instantaneous signal level Author

N74-13866 Radio and Space Research Station Slough (England)

STATISTICS OF HIGH-LEVEL BEYOND-HORIZON SIGNALS AT 2 2 GHz AND 2 6 GHz, AND MEASUREMENTS OF THE VARIATION OF THE ARRIVAL-ANGLE-STRUCTURE

M P M Hall *In* AGARD Propagation Effects of Freq Sharing Sep 1973 10 p refs (For availability see N74-13846 05-07)

Continuous recordings of field strength were made simultaneously over two 300 km troposcatter paths, one over land at 2 6 GHz and the other partly over sea at 2 2 GHz The recordings were made on 1 2 m diameter antennae at Chilbolton (near Winchester UK) Periodically the 25 m diameter steerable antenna was used to scan across the paths in bearing and elevation to determine the angular distribution of the arriving energy An analysis is presented of the high signal strengths exceeded for small percentages of the time, of the relative duration of these enhancement periods and of the changes in angular spread which occurred as the high signals built up and died away Results from an analysis of the cross correlation of the outputs from large and small antennas are presented in order to determine if phase cancellation of unwanted interference may be feasible during periods when interference signals on troposcatter paths become unacceptable high Author

N74-13867 Scripps Institution of Oceanography, La Jolla, Calif

HF MEASUREMENTS OF OCEAN-WAVE DIRECTIONAL SPECTRA

Robert H Stewart, Calvin Teague, Joseph W Joy, and G Leonard Tyler *In* AGARD Propagation Effects of Freq Sharing Sep 1973 7 p refs Prepared in cooperation with Stanford Univ (For availability see N74 13845 05-07)
(Contract N00014-69-A-0200 6012)

Bragg scattered HF radio waves were used to measure the directional spectrum of 0 14 Hz ocean waves during a time when they were in equilibrium with a constant and spatially homogeneous wind field The radio data consisted of monostatic measurements of LORAN A radio signals backscattered from the ocean These signals are pulsed, coherent, and vertically polarized and are resonantly scattered only by 0 14 Hz ocean waves moving radially toward or away from the transmitter receiver point The direction of arrival of the radio waves, and thus the directional distribution of the ocean wave energy, was determined by synthesizing a directional antenna having a maximum beamwidth of 5 10 deg The synthesis was done by moving the receiver along two nearly orthogonal paths using the runway and taxiways of the island The right-left ambiguity in the synthesized antenna was resolved by using a switched cardioid antenna which looked alternately to the right and the left as the basic receiving element The angular dependence of the ocean wave directional spectrum is presented as a function of wind speed Author

N74-13868 Hamburg Univ (West Germany) Inst fuer Radiometeorologie und Maritime Meteorologie

EXPLANATION OF VERY LOW FIELD STRENGTH LEVELS ON LINE-OF-SIGHT PATHS OVER SEA

H W Fruechtenicht *In* AGARD Propagation Effects of Freq Sharing Sep 1973 12 p refs (For availability see N74-13846 05-07)

Line of sight propagation over sea may be treated by ray tracing The method is applied to linear profiles and duct profiles of the refractive index The model calculation show that the receiving field passes through a number of interferences lobes if the duct thickness is increased This effect is verified by experiments Furthermore the theoretical considerations yield that the sea evaporation duct causes a certain antenna height, where the receiving field may vanish With increasing duct thickness, this special receiving point is shifted upwards Vertical polarization puts it on a lower level than horizontal polarization Moreover with increasing duct thickness it is shifted upwards more slowly for vertical polarization than for horizontal polarization Author

N74-13869 Servico de Telecomunicacoes Militares Lisbon (Portugal)

ANALYSIS OF 11 GHz BAND PROPAGATION IN PORTUGAL

J A Saraiva Mendes *In* AGARD Propagation Effects of Freq Sharing Sep 1973 8 p refs (For availability see N74 13846 05 07)

Supplemental attenuation due to rain at 11 GHz on paths 20 km long in different places of Portugal is estimated The cumulative distributions of clock hourly rain rates for Lisbon, Oporto and Coimbra are calculated and compared with those obtained directly from climatic data using the method proposed by Russak and Easley Then using the methods proposed by Quarta and by Boithias et al the cumulative distributions of instantaneous attenuation due to rain are also calculated for Lisbon Oporto and Coimbra The results obtained with both methods are compared and discussed It seems that the method proposed by Boithias et al cannot be widely used in Portugal However the reduction coefficients proposed by Boithias et al in order to obtain the equivalent rain rate along a path lead to distributions similar to those obtained with with the method proposed by Quarta The estimated supplemental attenuation in a path 20 km long at 11 GHz is about 35 db for 0 001% of the year and for paths orthogonal to the dominant winds Author

N74-13870 Department of Transportation, Cambridge Mass
MEASUREMENT OF ATMOSPHERIC ATTENUATION AT THE FREQUENCIES OF 16, 19, AND 34 GHz
George G Haroules, Wilfred E Brown, and Gregory J Bishop *In* AGARD Propagation Effects of Freq Sharing Sep 1973 14 p refs (For availability see N74-13846 05-07)

There are two methods of determining atmospheric attenuation without having to use a space vehicle In the first, attenuation may be measured by observing the extinction of an exoatmospheric source as a function of the zenith angle The second method depends upon the measurement of atmospheric emission from which the corresponding attenuation is calculated using an assumed atmospheric mean temperature The magnitude of atmospheric attenuation and the relative time interval of its occurrence at millimeter wavelengths must include consideration of the elevation angle of observation Knowledge of the percentage of time during which relatively high values of attenuation are observed is irrelevant without consideration of the elevation angle of observation at the time of occurrence Attenuation statistics resulting from a twelve month observation program are presented The sun is used as a source of microwave radiation The dynamic range of atmospheric attenuation measurement capability is in excess of 30 db Author

N74-13871 Army Satellite Communications Agency Fort Monmouth, N J
THE INTERRELATION OF PROPAGATION EFFECTS AND DESIGN FACTORS FOR FIXED SERVICE COMMUNICATIONS SATELLITE SYSTEMS
Billy J Fansler and S M Segner *In* AGARD Propagation Effects of Freq Sharing Sep 1973 11 p refs Prepared in cooperation with ECOM, Ft Monmouth, N J (For availability see N74-13846 05-07)

The problems of frequency sharing between multichannel transmission using satellites and multichannel transmission using radio relay are reviewed Two cases of potential interference involve determination of coordination distance based on normalized basic transmission in the absence and in the presence of precipitation One case is for the earth station received signal being interfered with by terrestrial station transmitters The second is for earth station transmitted signal interfering with terrestrial station receivers Taking advantage of a newly written computer program, the effects of varying propagation factors, radio climatic regions, rain climatic zones and interference duration is investigated Author

X74-73498 Advisory Group for Aerospace Research and Development Paris (France)
THE IDENTIFICATION OF MILITARY UTILIZATION OF FREQUENCY BANDS ABOVE 10 GHz
H J Albrecht Jul 1972 68 p
(AGARD AR 42)

NATO Restricted Report

The radio frequency spectrum below 10 GHz is rapidly reaching saturation National Authorities are actively considering a revision of the international allocation of the spectrum above 10 GHz In order that NATO Military Authorities may assure the satisfaction of NATO wide military requirements and be supported by adequate technical knowledge an overall NATO evaluation of the propagation parameters affecting the use of the spectrum above 10 GHz was necessary and is presented in this report

X74-73499 Advisory Group for Aerospace Research and Development Paris (France)
THE IDENTIFICATION OF MILITARY UTILIZATION OF FREQUENCY BANDS ABOVE 10 GHz
H J Albrecht ed Jun 1973 52 p Revised
(AGARD AR 42 Rev)

NATO Restricted Report

For abstract see X74-73498

08 COMPUTERS

Includes computer operation and programming, and data processing. For applications, see specific categories. For related information see also 19 Mathematics.

N72-11174# Advisory Group for Aerospace Research and Development, Paris (France)
ARTIFICIAL INTELLIGENCE
Thomas G. Evans, ed. Sep 1971 324 p refs Presented at AGARD Avionics Panel Tech Symp on Artificial Intelligence, Rome, 24-28 May 1971
(AGARD-CP-94-71) Avail NTIS HC $6.00/MF $0.95

The conference papers on artificial intelligence with emphasis on pattern recognition is reported. Other areas covered were robotry and robot vision, question-answering, natural language and speech recognition and man-machine interactive problem solving.

N72-11175# Grumman Aerospace Corp., Bethpage, N.Y.
ESTABLISHING REQUIREMENTS FOR ARTIFICIAL INTELLIGENCE IN THE AIRBORNE AND SPACE ENVIRONMENTS
Robert S. Aha *In* AGARD Artificial Intelligence Sep 1971 9 p refs (See N72-11174 02-08)
Avail NTIS HC $6.00/MF $0.95

Man-machine comparisons and basic requirement parameters for those most crucial operational problems for airborne, space, and non-terrain operations, wherein man must make use of artificial intelligence techniques, are delineated. Operational areas discussed are: safety of flight in flying close to the earth, missions for surveillance and reconnaissance operations, aircraft control in the vicinity of airports, space shuttle docking, and other critical operations. Author

N72-11176# Washington Univ., St. Louis, Mo. Dept. of Applied Mathematics and Computer Science
ROBOT DATA SCREENING: AN INTELLIGENT (?) DATA SEARCH TECHNIQUE
Theodor D. Sterling *In* AGARD Artificial Intelligence Sep 1971 8 p refs (See N72-11174 02-08)
Avail NTIS HC $6.00/MF $0.95

The process of robot data screening is described and an evaluation is made of its potential as a possible heuristic procedure to aid in sorting out the most important features in an aggregate of emperical observations. Robot screening uses a measure of relevance of variables derived from the usefulness of variables to serve as predictors for the outcomes of observations. It is pointed out that, although probability of correct cross-classification is a satisfactory method, entropy constitutes a more suitable criteria for determining relevance. In robot screening, the entropy produced with each cross classification is examined and those that indicate the largest change in entropy are selected. Special tests are then applied to each variable or variable combinations to see if its use is an improvement over the use of no or fewer predictors. As a final step, a search algorithm provides a practical method to converge upon the more useful cross-classification variable combinations. D.L.G.

N72-11177# Democritus Nuclear Research Center, Athens (Greece). Electronic Computers Div.
ON THE QUESTION ANSWERING SYSTEM DELFI AND ITS APPLICATION
J. Kontos and A. Kossidas *In* AGARD Artificial Intelligence Sep 1971 6 p refs (See N72-11174 02-08)
Avail NTIS HC $6.00/MF $0.95

The latest version of the question-answering system DELFI is described and examples of its application are given. DELFI is based on the automatic generation of programs that express the meaning of English-like sentences via a procedural intermediate language. The general characteristics of DELFI are mass storage data-base, variety of application, modular design and almost realistic scale of performance. The English-like sentences accepted by DELFI include statements, questions, commands, and conditional sentences. These sentences are parsed and translated by a grammar-directed semantic interpreter into programs in a high-level procedural language composed from procedural semantic components. The procedural semantic components used perform operations which are of logical, set processing, data flow control and program flow control kind respectively. The programs generated have access to the data-base for updating and retrieval. Examples of application of DELFI are given in data management, picture processing and simple problem solving. Author

N72-11178# IBM Italia, Rome
AN APPROACH TO NATURAL LANGUAGE FOR COMMAND AND CONTROL SYSTEMS
A. Lenzara *In* AGARD Artificial Intelligence Sep 1971 9 p refs (See N72-11174 02-08)
Avail NTIS HC $6.00/MF $0.95

The feasibility was examined of defining a highly user-oriented language, as close as possible to a natural language, for command and control systems. Several different language models were analyzed. Because of the recognized difficulty of computer programs to fully understand a natural language, the study goal was changed to the identification of a habitual language. The suitability of different models to describe the habitual language is discussed and the most promising model is selected. Possible methodology to be used to tailor the model to a particular command and control environment is also discussed. D.L.G.

N72-11179# Rome Air Development Center, Griffiss AFB, N.Y.
AUTOMATIC SPEAKER RECOGNITION SYSTEMS
Bruno Beek, James Grech, and Willard F. Meeker (RCA, Camden, N.J.) *In* AGARD Artificial Intelligence Sep 1971 7 p refs (See N72-11174 02-08)
Avail NTIS HC $6.00/MF $0.95

Two systems, with variations, for speaker recognition are described. The recognition decisions are made automatically from continuous speech uncontrolled as to context. One system uses primarily pitch and spectral characteristics obtained from voiced sounds. The other system employs automatic speech recognition circuitry to extract phonemes so that the spectral characteristics of each phoneme type can be tabulated separately. The characteristic manner in which individual phonemes are pronounced by different speakers is used to identify or differentiate between speakers. Results obtained with 30 speakers are presented. Author

N72-11180# National Research Council of Canada, Ottawa (Ontario). Control Systems Lab.
EXPERIMENTS WITH A HEURISTIC ON-LINE PICTURE PROCESSING LANGUAGE
T. Kasvand *In* AGARD Artificial Intelligence Sep 1971 6 p (See N72-11174 02-08)
Avail NTIS HC $6.00/MF $0.95

A short description of a heuristic picture processing, learning and recognition system is outlined. It is shown that it is possible to construct a pattern recognition system which is independent of picture content. The objects in the picture are fragmented (if they are complicated) descriptions for the fragments (atoms) are formed and normalized before they are recognized. The inter-relationships between the atoms composing an object are stored during recognition these inter relationships are used in a procedure resembling hypotheses testing. A simplified version of the proposed system was programmed and gave adequate results. Author

N72-11181# Communications Research Centre, Ottawa (Ontario)
WEATHER RADAR IMAGE PROCESSING

A W Bridgewater *In* AGARD Artificial Intelligence Sep 1971 13 p refs (See N72-11174 02-08)
Avail NTIS HC $6 00 MF $0 95

The use is explored of computer image-processing for feature extraction in PPI displays of radar backscatter. The picture is transformed or 'processed' in order to reveal to the human analyst certain structural parameters of the patterns which are not directly accessible by visual inspection. Once identified, these parameters are extracted automatically and summary statistics of precipitation characteristics can be built up for long sequences of pictures. In the search for suitable features to describe the attenuation phenomena, the two-dimensional autocorrelation function of the image is shown to be useful. It is implemented digitally using the fast Fourier transform algorithm and it results in relatively regular, smoothly contoured structures which indicate average measures of ellipticity, directivity, periodicity, and correlation distances of the echo patterns. Data reduction methods for quantifying and extracting these features are described. Author

N72-11182# Plessey Co. Ltd Havant (England) Electronics Research Lab
A PRACTICAL APPLICATION OF PATTERN RECOGNITION
C J W Mason and O E Morgan *In* AGARD Artificial Intelligence Sep 1971 8 p ref (See N72-11174 02-08)
Avail NTIS HC $6 00 MF $0 95

A study was made of the application of pattern recognition techniques, using partitioning of data in n-space, to the detection of personnel who may be moving at a rate comparable with that of a clutter-producing environment. The sensor employed was a Doppler radar. Details of the processing and results are given. Feasibility of the techniques is demonstrated. Author

N72-11183# Transportation Systems Center, Cambridge Mass
AUTOMATIC DETECTION OF VEHICLES IN AERIAL PHOTOGRAPHS OF HIGHWAYS
Juris G Raudseps *In* AGARD Artificial Intelligence Sep 1971 8 p (See N72-11174 02-08)
Avail NTIS HC $6 00 MF $0 95

The problem of time and effort involved in the data reduction process with information obtained through aerial photographs of highways is dealt with. An approach to automating the data reduction process is described. Techniques from the fields of interactive computer graphics and automatic pattern recognition are used in combination to reduce the amount of human effort required. A computer - controlled flying - spot scanner is used to scan the photographs. By means of a graphics tablet and stylus, a human operator selects ground reference points, delineates road boundaries, and may mark vehicles. The computer extrapolates the trajectories of vehicles to predict their positions in successive photographs. Their precise locations are then determined and recorded by applying pattern recognition techniques, matching the vehicle images in the current frame against their recorded images in the previous frame of photography. Author

N72-11184# Purdue Univ Lafayette Ind School of Electrical Engineering
AUTOMATIC MEDICAL DIAGNOSIS USING NONPARAMETRIC SEQUENTIAL CLASSIFICATION PROCEDURES
K S Fu and M H Loew *In* AGARD Artificial Intelligence Sep 1971 9 p refs (See N72-11174 02-08)
(Grant AF-AFOSR-1776-69)
Avail NTIS HC $6 00 MF $0 95

Two nonparametric sequential classification procedures are applied to medical diagnosis problems. The procedures include (1) sequential classification using nonparametric partition, and (2) sequential classification using nonparametric ranking. Specific results of some real-data medical diagnosis are presented for the problems of separating primary liver cancer from primary cancer of the pancreas, and for the separation of those from normal cases. The measurements (features) used are blood chemistry and hematology values, urinalysis, X-ray and liver scan results, and ECG and EEG analysis. Classifications for the training data were determined according to the patients' most recent diagnosis, either by biopsy at surgery or pathology at autopsy. The results obtained from these two proposed procedures are compared and their corresponding advantages and disadvantages are discussed. Author

N72-11185# Bunker-Ramo Corp. Westlake Village Calif
FIXED AND ADAPTIVE ALGORITHMS FOR PATTERN RECOGNITION PROBLEMS IN THEORY AND APPLICATION
C M Bertone and F A Muckler (Manned Systems Sci. Inc) *In* AGARD Artificial Intelligence Sep 1971 13 p refs (See N72-11174 02-08)
Avail NTIS HC $6 00 MF $0 95

Based on recent Soviet and American theoretical developments, information is presented on adaptive and self-organizing algorithms and problems in applications, specifically in multiple sonar input processing and voice encoding. In addition, detailed descriptions are given of Soviet work in computer-aided medical diagnostics. Author

N72-11186# Carnegie-Mellon Univ. Pittsburgh, Pa Dept of Computer Science
COMPUTER PROCESSING OF NATURAL SCENES: SOME UNSOLVED PROBLEMS
Ugo Montanari (CNR, Pisa, Italy) and Raj Reddy *In* AGARD Artificial Intelligence Sep 1971 5 p refs (See N72-11174 02-08)
(Contract F44620-70-C-0107)
Avail NTIS HC $6 00 MF $0 95

The problem is considered of extending the present methods used in visual image processing to the analysis of natural scenes. The limitations are discussed of presently used techniques such as edge detection algorithms, two-dimensional Fourier transforms and linguistic methods. In addition, recommendations are proposed for future research in processes which appear to be promising. D L G

N72-11187# Consiglio Nazionale delle Ricerche, Rome (Italy)
KINEMATIC ASPECTS OF PROJECT OF UNCONVENTIONAL LOCOMOTION VEHICLES
T Leo and R Vitelli *In* AGARD Artificial Intelligence Sep 1971 10 p refs (See N72-11174 02-08)
Avail NTIS HC $6 00 MF $0 95

The development is reported of an unconventional locomotion vehicle, capable of moving on jointed legs and performing rectilinear displacements on an horizontal plane. Movement is automatically controlled by input signals but the degree of control is limited to translational speed. The problem considered involves the additional development of a steering control system. A theoretical study is described in which a heuristic approach to the problem is taken. The minimum possible number of degrees of freedom are used and stability conditions of vehicle motion and other given constraints on locomotion are respected. In addition, complete automation of the vehicle is maintained. D L G

N72-11188# Aerojet-General Corp Azusa Calif
RECOGNIZING THREE DIMENSIONAL OBJECTS BY THEIR SILHOUETTES
J Sklansky and G A Davison, Jr *In* AGARD Artificial Intelligence Sep 1971 11 p refs Prepared in cooperation with Calif Univ Irvine (See N72-11174 02-08)
(Contract F33615-69-C-1314)
Avail NTIS HC $6 00 MF $0 95

A method is described for classifying or identifying a three-dimensional object from one or more of its silhouettes. The method is based on a low-cost parallel mechanism for computing the slope density of the edge of the silhouette. The proposed technique computes the slope density by a circularly nutating array of photodetectors. The slope density is then passed through a set of narrow-band-pass filters, yielding the Fourier harmonics of the slope density. In order to take account of varying aspect angles of the original object, the object is

represented by a number of prototypes, each prototype being a vector of the Fourier harmonics of the slope density. These prototypes appear in a decision tree that makes the final recognition. An experimental machine implementing this technique is described, and the results obtained with the machine for recognizing five classes of aircraft are given. Author

N72-11189# Texas Univ., Austin. Dept. of Electrical Engineering.
SEQUENTIAL STRUCTURE AND PARAMETER ADAPTIVE PATTERN RECOGNITION. PART 1: SUPERVISED LEARNING
D. G. Lainiotis. *In* AGARD Artificial Intelligence Sep. 1971 11 p refs (See N72-11174 02-08)
(Grants AF-AFOSR-1764-69; AF-AFOSR-0768-67E)
Avail: NTIS HC $6.00/MF $0.95

Recursive filters for supervised learning Bayes-optimal adaptive pattern recognition with continuous data are derived. Both off-line (or prior to actual operation) and on-line (while in operation) supervised learning is considered. The concept of structure adaptation is introduced and both structure as well as parameter adaptive optimal pattern recognition systems are obtained. Specifically, for the class of supervised learning pattern recognition problems with Gaussian process models and linear dynamics, the adaptive pattern recognition systems are shown to be decomposable into a linear, non-adaptive part consisting of recursive, matched Kalman filters, a nonlinear part consisting of a set of probability computers that incorporates the adaptive nature of the system, and finally a linear part of the correlator-estimator form. Extensions of the above results to the M-ary hypotheses cases, where M > or = 2 are given. Author

N72-11190# North American Rockwell Corp., Thousand Oaks, Calif. Science Center.
SEMI-ADAPTIVE APPROACH TO PATTERN RECOGNITION
John M. Richardson. *In* AGARD Artificial Intelligence Sep. 1971 7 p refs (See N72-11174 02-08)
Avail: NTIS HC $6.00/MF $0.95

Two kinds of approaches to pattern recognition, representing extreme limits of the adaptive-nonadaptive axis, are considered. These include (1) the adaptive approach in which the prior information is composed mainly of pre-classified training patterns with a very limited amount of information designed into the system, and (2) the nonadaptive approach in which the prior information is composed entirely of information designed into the system. Emphasis is placed on deriving some intermediate approaches by combining various aspects of the two described approaches. The methodology employed involves the use of mathematical models of pattern classes to which decision theory is applied. The models, although stochastic, are partially indeterminate in the sense that some of the probability parameters are not completely known. In the adaption phase both Bayesian and non-Bayesian techniques are considered for the reduction of model indeterminacy through pre-classified samples. D.L.G.

N72-11191# Manufacture Belge de Lampes et de Materiel Electronique, Brussels (Belgium).
A GENERAL ORDER MINKOWSKI METRIC PATTERN CLASSIFIER
Pierre A. Devijver. *In* AGARD Artificial Intelligence Sep. 1971 11 p refs (See N72-11174 02-08)
Avail: NTIS $6.00/MF $0.95

One general category of multiclass deterministic pattern recognition systems is defined by a linear structure in the input variables and an analytical criterion. This criterion requires the minimization of the average pth power of one Minkowski distance measure of order p in one particular decision space. Analytical reasoning indicates that the criterion yields an error-correcting procedure. The procedure results in a reduction of the number of misclassifications when the order of the criterion metric is increased. This feature renders the criterion particularly well suited to nonseparable problems. It is briefly mentioned how this design criterion may be used to produce optimized decision surfaces in the separable two class case, as it tends to maximize the minimum distance from each class to the decision surface. The Bayesian distribution-free classifier appears as a special case of the general category of classifiers defined by the criterion. Author

N72-11192# Florida Univ., Gainesville. Center for Informatics Research.
PREPROCESSING FOR PICTORIAL PATTERN RECOGNITION
R. H. Cofer and J. T. Tou. *In* AGARD Artificial Intelligence Sep. 1971 13 p refs (See N72-11174 02-08)
(Contract N00014-68-A-0173-0001)
Avail: NTIS HC $6.00/MF $0.95

An integrated preprocessing system is presented for the purpose of line extraction. This system consists of six stages, each of which reduces an abstract, i.e. defined, line network of a picture to a form which represents the physical line structure more meaningfully or efficiently. In operation, the picture is first stripped of all spurious objects and holes. A connected medial axis is then found for each object in order to reduce the line width. This is followed by removal of all 4-point loops, resulting everywhere in abstract lines of unit thickness. Noise branches, a natural result of the prior processing techniques, are then removed. For greater processing flexibil[illegible] the abstract line structure is then inserted into a list data structure composed of line, junction, and endpoint entries. Th[illegible] resulting structure is then further processed in order [illegible] the representation of those junctions of many lines. Th[illegible]al representation of the picture serves as an ordered, high level data base upon which further pattern analysis, recogn[illegible], or processing may be conducted. Author

N72-11193# Philips Gloeilampenfabrieken N. V., Eindhoven (Netherlands).
A NAIVE METHOD FOR MACHINE RECOGNITION OF HAND WRITTEN NUMERALS
M. Beun. *In* AGARD Artificial Intelligence Sep. 1971 10 p refs (See N72-11174 02-08)
Avail: NTIS HC $6.00/MF $0.95

A method for character recognition by machines is described. The character to be recognized is scanned to obtain a matrix of black and white dots, to which a thinning process is then applied. This process, which has built in a precaution not to destroy connectivity, produces a skeleton of which no further point can be removed without either destroying connectivity or eating away end points. Features as end points and junctions are now readily detected and their occurrence and relative positions provide the basis of a recognition scheme. The recognition scheme is so made up that more and finer recognition criteria can be added when needed, without basically affecting the recognition possibilities already attained. Moreover, as more experience is gained as to the most effective criteria, a completely fresh start often produces a new recognition scheme that is simpler and more powerful than its predecessors. Author

N72-11194# Siemens A.G., Munich (West Germany).
HOLOGRAPHIC PATTERN RECOGNITION USING A MULTICHANNEL CORRELATOR
G. Winzer and N. Douklias. *In* AGARD Artificial Intelligence Sep. 1971 12 p refs Sponsored by Bundesmin. fuer Bildung und Wiss. (See N72-11174 02-08)
Avail: NTIS HC $6.00/MF $0.95

A multichannel correlator for holographic matched filtering is described. The channels are separated spatially in the Fourier-plane. This arrangement allows individual filters to be realized for each channel for different spatial frequency ranges etc. The multichannel correlator is addressed by a generator of multiple object waves, i.e. by different directions of object illumination. Parallel and sequential evaluation of the correlation signals is possible. The efficiency and signal-to-noise ratio for

both modes of operation are discussed. In each channel linear superimposed multiple Vander-Lugt filters may be introduced to increase the overall capacity of learning steps. The risk of overexposure is very small because the centers of the frequency spectra are separated on the hologram filter plate. With a multichannel correlator combined matched and feature filtering may be performed. Preliminary experimental results show that this method can be successfully used in some cases where the results of simple matched filtering remain unsatisfactory. The results and discussions are presented from a more general point of view with some remarks concerning comparable methods and possible future aspects. Author

N72-11195# Fraunhofer-Gesellschaft zur Foerderung der Angewandten Forschung e. V., Karlsruhe (West Germany). Inst. fuer Informationsverarbeitung.
OPTICAL PATTERN PROCESSING FOR RECOGNITION
E. Muehlenfeld *In* AGARD Artificial Intelligence Sep. 1971 7 p refs (See N72-11174 02-08)
Avail: NTIS $6.00 MF $0.95

Optical processing is discussed as a useful tool for compressing pattern information by feature extraction. Topics discussed include compression of pattern information, recognition of pattern vectors, and parallel processing. F.O.S.

N72-11196# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Satellitenelektronik.
AN IMAGE PROCESSING AND PATTERN RECOGNITION SYSTEM FOR TIME VARIANT IMAGES USING TV CAMERAS AND A MATRIX COMPUTER
Ernst E. Triendl *In* AGARD Artificial Intelligence Sep. 1971 10 p (See N72-11174 02-08)
Avail: NTIS HC $6.00 MF $0.95

An artificial visual system is discussed with desirable characteristics similar to those of a mammalian visual system. The general structure is described and includes: sensors, cameras, video reduction and input to the matrix processor, and master computer. F.O.S.

N72-11197# Technische Hogeschool, Delft (Netherlands).
THE STORAGE OF VIDEO INFORMATION IN A MEMORY
P. H. T. VanDerMeer *In* AGARD Artificial Intelligence Sep. 1971 7 p ref (See N72-11174 02-08)
Avail: NTIS HC $6.00 MF $0.95

The basic principles of the video-to-digital converter for storage of video information with small memory systems are presented. A composite video signal generated by the TV camera is considered to be made up of a brightness and a synchronization signal. The output of the converter consists of the brightness in a binary form, which is transferred to the core memory of a PDP 9 computer. Information reduction and compression limit the number of memory places required for storage of TV images. F.O.S.

N72-11198# University Coll., London (England). Dept. of Physics.
CELLULAR LOGIC AND ITS SIGNIFICANCE IN PATTERN RECOGNITION
M. J. B. Duff *In* AGARD Artificial Intelligence Sep. 1971 13 p refs (See N72-11174 02-08)
Avail: NTIS HC $6.00 MF $0.95

The use of cellular logic in the solution of pattern recognition problems is discussed. Two classes of cellular logic arrays were investigated for pattern preprocessing. The class consists of variable function arrays with nearest neighbor connection and the other depends on switching circuits linked by diodes. F.O.S.

N72-11199# Vanderbilt Univ., Nashville, Tenn.
A MAN-MACHINE APPROACH TOWARD SOLVING VARIOUS ROUTING, SCHEDULING, AND NETWORK PROBLEMS
Patrick Krolak, Wayne Felts, and James M. Nelson *In* AGARD Artificial Intelligence Sep. 1971 12 p refs (See N72-11174 02-08)
(Grant NSF GK-4975)
Avail: NTIS HC $6.00 MF $0.95

A man-machine approach is presented for solving problems of the following types: traveling salesman, generalized truck dispatching, board wiring, and construction of minimum cost communication networks with survival or redundancy demands. The truck dispatching problem is considered in detail, and the man-machine process, data organization, computer heuristics, and the interactive phase are discussed. F.O.S.

N72-11200# Bell Aerospace Co., Buffalo, N.Y.
PROCESSING AND DISPLAY OF TIME VARYING SPECTRAL INFORMATION WITH APPLICATION TO SONAR, VOICE, AND MEDICAL SIGNALS
Lester A. Gerhardt *In* AGARD Artificial Intelligence Sep. 1971 12 p refs Prepared in cooperation with Rensselaer Polytech. Inst. (See N72-11174 02-08)
(Contract AF 49(638)-1627)
Avail: NTIS HC $6.00 MF $0.95

The representation of a nonstationary signal by a time varying spectral display (TVSD) is described. Methods of generating the information used in a TVSD are discussed, with emphasis on on-line real time techniques. Several methods of displaying this information are presented, including computer and television generated images. General examples of processing the time varying spectral data are given with respect to periodic and aperiodic signal features. The applications of the TVSD are also presented. Selected research in the fields of Sonar, Voice, and Medical signal processing is discussed. The usefulness of the TVSD is demonstrated by examples using the lofargram, voiceprint, and phonocardiogram in each of these three fields, respectively. Author

N72-11201# General Electric Co., Syracuse, N.Y.
SIGNAL ANALYSIS AND CLASSIFICATION BY INTERACTIVE COMPUTER GRAPHICS
A. W. Whitney and W. E. Blasdell *In* AGARD Artificial Intelligence Sep. 1971 10 p refs (See N72-11174 02-08)
(Contract F30602-69-C-0227)
Avail: NTIS HC $5.00 MF $0.95

Many aspects of signal analysis and classification are briefly discussed and techniques are given for employing an interactive computer graphics facility to design signal classification systems. The signal classification problems addressed are characterized by the fact that the classification information present in the signals must be extracted from a limited number of identified signals. Author

N72-11202# Rome Air Development Center, Griffiss AFB, N.Y.
ON THE DESIGN OF WAVEFORM CLASSIFICATION SYSTEMS BY INTERACTIVE MAN-MACHINE METHODS
H. E. Webb, Jr. and D. H. Foley *In* AGARD Artificial Intelligence Sep. 1971 19 p refs (See N72-11174 02-08)
Avail: NTIS HC $6.00 MF $0.95

A waveform processing system is proposed for feature extractor design. The editing, transformation, basic function expansion, digital filtering, and local feature operation are described. An on-line pattern analysis and recognition system is also discussed as a research tool for aiding analysts in designing classification logic. Author

N72-11203# International Computers Ltd., Kidsgrove (England).
NEW TECHNIQUES IN INTERACTIVE GRAPHIC CONSOLE DESIGN FACILITATING THE PRESENTATION AND MANIPULATION OF COMPLEX DATA
G. Hughes *In* AGARD Artificial Intelligence Sep. 1971 9 p refs (See N72-11174 02-08)
Avail: NTIS HC $6.00 MF $0.95

An experimental method by which the techniques of interactive line graphics may be extended to the handling of

pictoral data is described. This involves a combination of a new storage scan converter with conventional digital incremental computational techniques. Indications are made as to how the method may be applied to pattern recognition and visual artificial intelligence problems and the manner in which the system may be enhanced to cater for color pictures is outlined. In addition to the above enhancements to cater for picture manipulation an enumeration of the problems in display presentation of pictorial data in an interactive terminal and a potential method of enhancement is briefly described. Author

N72-11204# Compagnie Generale de Telegraphie sans Fil, Paris (France)

DIGITAL FILTERING PROCEDURES FOR A LINE IMAGE [PROCEDES DE FILTRAGE DIGITAL D'UNE IMAGE DE LIGNES]

J. C. Simon and A. Checroun *In* AGARD Artificial Intelligence Sep. 1971 14 p refs In FRENCH; ENGLISH summary (See N72-11174 02-08)

Avail: NTIS HC $6.00 MF $0.95

The use of computers to analyze data which modifies the usual representation concepts are discussed. The following constraints introduced by computers are analyzed: digitization, memory size, and algorithmic treatments. An adaptation of the conventional filtering processes of an image leads to digital filters, which are well suited to arithmetic computation. These principles are applied to the optimal storage of an image, to the reduction of information volume, and to the first level features extractions. The PPI radar information is processed by these methods. The aim is to reduce the available information to a few specific features that will describe a radar situation. Hill ridges are such features. They are automatically extracted and represented by lines, which are then coded and stored. Author

N72-11205# Karlsruhe Univ. (West Germany). Inst. for Inform. and Transmission

GENERATION OF LINE DRAWINGS FROM GREY-SCALE PICTURES

F. Holdermann and H. Kazmierczak *In* AGARD Artifial Intelligence Sep. 1971 14 p refs (See N72-11174 02-08)

Avail: NTIS HC $6.00 MF $0.95

The problem of detecting boundaries of objects in gray scale pictures is studied. An object is defined as a region with a reasonable uniform distribution of intensities. Three methods are presented and the results of their applications to some areal photos are discussed. The detected boundaries are given by differential line elements which are described in each picture point by a direction, characterizing the orientation of the boundary, and by a weight characterizing the amount of the gradient of the intensity distribution. A filtering and a contour tracing algorithm, based on the direction and weight information of the boundaries are briefly discussed. Author

N72-11206# Technical Univ. of Denmark, Lyngby. Electronics Lab.

PATTERN RECOGNITION USING DYNAMIC PICTORIAL INFORMATION

Peter W. Becker and Knud A. Nielson *In* AGARD Artificial Intelligence Sep. 1971 6 p refs (See N72-11174 02-08)

Avail: NTIS HC $6.00/MF $0.95

Problem solving with man-machine interaction was considered for pattern recognition using both static and dynamic information. Topics discussed include: recognition of handprinted digits, recognition logic, dynamic attributes, and static attributes. It is concluded that the use of dynamic pictorial information simplifies recognition of picture patterns. F.O.S.

N72-21211# Advisory Group for Aerospace Research and Development, Paris (France)

COMPUTERS IN THE GUIDANCE AND CONTROL OF AEROSPACE VEHICLES

C. T. Leondes, ed. (Calif. Univ., Los Angeles) Feb. 1972 265 p refs

(AGARDograph-158; AGARD-AG-158) Avail: NTIS

The utilization of computer technology in aerospace systems is examined in detail. Three major areas are considered: (1) system design techniques, (2) systems hardware techniques, and (3) guidance and control computer systems applications. For individual titles, see N72-21212 through N72-21227.

N72-21212# North American Rockwell Corp., Anaheim, Calif.

OVERVIEW OF AEROSPACE VEHICLE COMPUTER APPLICATIONS

Gordon H. Smith *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb. 1972 p 1-7 (See N72-21211 12-08)

Avail: NTIS

A brief historical treatment is presented of the application of digital computing techniques to aerospace systems. The technological developments in both hardware and system application are summarized and the impact of new technologies is discussed. Problems which have developed in applying digital computers in real time control systems are identified along with successful solutions to those problems. Author

N72-21213# International Business Machines Corp., Owego, N.Y. Electronics Systems Center

FEDERATED VS INTEGRATED COMPUTER SYSTEMS

James H. Crenshaw *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb. 1972 p 9-22 refs (See N72-21211 12-08)

Avail: NTIS

The computer system organizations utilized in current aerospace systems and design considerations for developmental systems are reviewed. The advantages and disadvantages of the federated and integrated approaches are analyzed and the system dependent variables which must be considered by the designer are discussed to emphasize the real world situation. Features such as vulnerability to battle damage and graceful degradation are considered along with the queuing theory, waiting time, and loading factor. Author

N72-21214# Teledyne Systems Co., Northridge, Calif.

GUIDANCE AND CONTROL COMPUTER SYSTEM DESIGN

Earl Kanter *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb. 1972 p 23-43 (See N72-21211 12-08)

Avail: NTIS

The subject of logical organization of typical aerospace computers is considered from the standpoint of integrated circuit technology and architectural requirements. First a proposed circuit technology amenable to a flexible mechanization of modern architecture is presented. Then, two general classes of computer systems design are discussed, utilizing this circuit technology. The two general classes are represented by a special purpose guidance and control computer and a general purpose computer programmable for a guidance and control application. Author

N72-21216# North American Rockwell Corp., Downey, Calif.

REAL TIME PROGRAMS FOR AEROSPACE VEHICLES

Victor Strand and L. J. Andrews (IBM Corp., Huntsville, Ala.) *In* AGARD Computers in the guidance and control of Aerospace Vehicles Feb. 1972 p 45-56 (See N72-21211 12-08)

Avail: NTIS

An overview is presented of the developmental and technical considerations associated with the generation and checkout of computer programs for real time control of aerospace vehicles. Technical topics include a discussion of executive programs, program growth, program modularity, fixed vs. floating point arithmetic, higher order languages, etc. The software preliminary and baseline designs, documentation, verification, validation, models, monitors and program management are discussed as they affect the production and checkout of real time aerospace software. A brief dissertation on future efforts and considerations is also presented. Author

N72-21216# Singer-Librascope, Glendale, Calif

PROGRAMMING CHARACTERISTICS OF FUTURE G AND C COMPUTERS

Austin J. Maher *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 57-63 refs (See N72-21211 12-08)

Avail NTIS

The types of difficulties encountered in developing and maintaining airborne computer programs are reviewed. These include problems encountered in the initial development of the system program and the significant changes to the original program based on laboratory and flight tests of the over-all system. By assimilating results of previous system development experience and predicting the trends in airborne computer hardware development, characteristics are proposed for future airborne Guidance and Control computers. The proposed computer characteristics would minimize significant programming difficulties while retaining desirable hardware features (e.g., protected memory, small size, etc.). The features covered include word length tradeoffs, type of arithmetic, addressing techniques, subprogram linkages, etc., and in summary represent a functional specification for a class of future airborne computers using MSI or LSI techniques. Finally, the specific characteristics are presented of an airborne computer designed to meet these functional specifications. Author

N72-21217# International Business Machines Corp., Owego, N.Y. Electronics Systems Center

AEROSPACE COMPUTER WORD LENGTH CONSIDERATIONS

G. W. Braudaway and C. J. Standish *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 65-71 refs (See N72-21211 12-08)

Avail NTIS

A number of data word and instruction format factors are described which must be considered when selecting the length(s) of instructions and data words to be implemented in an aerospace computer. The primary emphasis is on selection of data-word and instruction lengths under the constraint that data and instruction lengths are compatible. This is, the data-word length is an integral multiple of the instruction word length. This implementation is appropriate when data and instructions are to be stored in the same area of memory. In a section devoted to storage efficiency, the effects on implementation of removing this compatibility constraint are examined. Examples drawn from avionic navigation computations are used to illustrate the premise that variable word length arithmetic can be used to produce numeric results equivalent to those produced by uniform word length arithmetic while reducing storage requirements substantially. Additional storage savings can result from use of variable length instruction formats. The need is demonstrated for continued development of programming techniques for utilizing variable word length arithmetic and instruction formats efficiently. Author

N72-21218# Sperry Rand Corp., St. Paul, Minn. Univac Div

AEROSPACE COMPUTER MEMORY TECHNIQUES

J. R. Erhardt, K. L. Pearson, W. S. Makos, and E. J. Torok *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 73-82 refs (See N72-21211 12-08)

Avail NTIS

Current avionics and aerospace memory technology are described, and the techniques available in today's production systems as well as those soon likely to be in production are reviewed. Three major categories are discussed: magnetic memories, semiconductor memories and mass memory applications of plated wire, and thin film and domain wall propagation techniques. Author

N72-21219# Teledyne Systems Co., Northridge, Calif

AEROSPACE COMPUTER INPUT-OUTPUT TECHNIQUES

P. K. Hammond and W. T. Palmer *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 83-91 (See N72-21211 12-08)

Avail NTIS

The design philosophy applied to the interfacing elements of an aerospace computer is discussed in terms of establishing the overall performance, reliability, maintainability, and cost of the system. Most of the key functional requirements which should be considered in the design phase of interfacing equipment are reviewed. Author

N72-21220# Bendix Corp., Teterboro, N.J. Navigation and Control Div.

FAULT ISOLATION IN A DIGITAL GUIDANCE AND CONTROL COMPUTER

David H. Blauvelt *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 93-98 (See N72-21211 12-08)

Avail NTIS

The possibility is examined of a general purpose digital computer being able to realize an optimum fault isolation capability in a guidance and control application. It is shown that if proper attention is given to the functional partitioning of the computer, self-test and self-diagnostic programs can be written which will determine that faults have occurred and will isolate them to the replaceable card level. It is also demonstrated that this can be accomplished with virtually no additional flight hardware and a relatively simple test console which allows maintenance personnel to communicate with the computer in question. Author

N72-21221# Hughes Aircraft Co., Culver City, Calif. Aerospace Group.

GUIDANCE AND CONTROL COMPUTER ACTUATED DISPLAY SYSTEM TECHNIQUES

G. K. Slocum, J. W. Gunvordahl, M. Weihrauch, and J. W. Weber *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 99-115 ref (See N72-21211 12-08)

Avail NTIS

The airborne computer is discussed in its relationship to the display systems it drives, and to the part that the crew plays in the management and control processes. These relationships are considered for current and near-term tactical aircraft systems with an outlook to the possibilities for the future. Author

N72-21222# Teldix Luftfahrt-Ausruestungs G.m.b.H., Heidelberg (West Germany).

SYSTEMS TASKS FOR ADVANCED AIRCRAFT NAVIGATION SYSTEMS

F. G. Unger and R. S. Sindlinger *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 117-130 refs (See N72-21211 12-08)

Avail. NTIS

Conventional navigation systems are described and compared with advanced systems proposed for military aircraft with instrumentation that would include an inertial platform, a Doppler radar, means for position fixing, and back-up devices such as air data units, magnetic compasses, etc. The additional tasks that would then be required of the navigation computer and data processing equipment are summarized. Possible hardware solutions are outlined and approaches to developing optimal equipment configurations are examined. K.L.G.

N72-21223# Teledyne Systems Co., Northridge, Calif

HELICOPTER GUIDANCE AND CONTROL COMPUTER SYSTEMS

Lawrence A. Kaufman *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb 1972 p 131-155 (See N72-21211 12-08)

Avail NTIS

The use of central digital computers for helicopter avionic

system functions is examined and it is shown how the use of such techniques has evolved as a consequence of the application of helicopters in increasingly more complex missions. The first of these new helicopter digital systems to be developed, the U.S. Marine Corps Integrated Helicopter Avionic System (IHAS), is described in terms of the conceptual design approaches used. The system syntheses problems which are experienced using digital computation techniques are analyzed. Future trends for the application of central digital computers for both helicopters and VTOL aircraft are indicated. Author

N72-21224# Litton Systems, Inc., Woodland Hills, Calif. Guidance and Control Systems Div.
INTEGRATED INERTIAL DOPPLER LORAN COMPUTER GUIDANCE AND CONTROL
Robert G. Berfield and William O. Felsman *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb. 1972 p 157-174 (See N72-21211 12-08)
Avail: NTIS

The navigation/guidance computer requirements for a typical, integrated inertial-Doppler-loran mechanization are outlined, and the techniques are described for generating an efficient and accurate operational program. Author

N72-21225# ITT Avionics, Nutley, N.J.
COMPUTERS FOR LORAN C/D AND OMEGA NAVIGATION AND GUIDANCE SYSTEMS
James P. VanEtten and Gerald P. Zemlin *In* AGARD Computers in the Guidance Control of Aerospace Vehicles Feb. 1972 p 175-228 refs (See N72-21211 12-08)
Avail: NTIS

A synopsis is given of geometry fundamentals pertinent to position-accuracy assessment, the fundamentals of both the loran C/D and Omega systems (including technical summaries of low-frequency and very-low-frequency propagation), and the general effects of vehicle dynamics on system implementation. The application of the modern airborne digital computer to radio navigation signal processing tasks such as signal acquisition and signal tracking is described for both loran C/D and Omega, using advanced radio navigation sensor design approaches as a basis. The more common application of computers to the task of converting from hyperbolic radio coordinates to geographic coordinates of latitude and longitude, and from these to UTM northing and easting, is treated, and the problems entailed in correcting these geographic coordinates for variations in radio propagation are also addressed. Simplified techniques for application of hyperbolic radio navigation data to guidance functions are discussed. Finally, the implications of loran C/D and Omega processing tasks toward establishment of efficient architecture for airborne computers, are discussed, and short tables of desired instructions listed in order of importance are presented. Author

N72-21226# TRW Systems Group, Redondo Beach, Calif. Guidance and Navigation Lab.
COMPUTERS FOR SATELLITE BASED NAVIGATION AND GUIDANCE SYSTEMS
T. L. Rodrick and T. I. Fine *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb. 1972 p 229-245 refs (See N72-21211 12-08)
Avail: NTIS

The considerations involved in selecting a computer for an airborne navigation satellite user are examined. The software is described which will be used by navigation satellite users and which determines the user's computer requirements. The navigation satellite systems which are treated, are ranging or range differencing systems in which the user is passive (does not transmit to the satellite). The software is described in modular fashion to illustrate how a variety of user needs can be satisfied by different combinations of the same modular components. A description of the Kalman filter design considerations for a combined navigation satellite/inertial system is included which shows how computer speed and memory requirements depend upon the filter state vector size. Author

N72-21227# International Business Machines Corp., Owego, N.Y. Electronics Systems Center.
COMPUTERS FOR THE GUIDANCE AND CONTROL OF TACTICAL AIRCRAFT
W. J. Bernhart *In* AGARD Computers in the Guidance and Control of Aerospace Vehicles Feb. 1972 p 247-268 (See N72-21211 12-08)
Avail: NTIS

The navigational and guidance function provided a typical tactical application by utilization of a digital computer mechanization is analyzed. A brief description is given of the methods utilized to accomplish these functions and the sensors utilized in displaying pilot information and system configuration. The capabilities afforded the tactical vehicle by using digital devices for computation of navigational and guidance algorithms are summarized. Author

N72-22168# Advisory Group for Aerospace Research and Development, Paris (France).
IMAGE STORAGE AND TRANSMISSION SYSTEMS FOR THE DISSEMINATION OF INFORMATION
Feb. 1972 44 p refs Conf. Proc. Presented at Joint Meeting, Oslo, 9 Sep. 1971
(AGARD-CP-92) Avail: NTIS

Advanced systems of data processing are presented which involve the storage, retrieval, transmission, and reproduction of alphanumeric and pictorial data. Emphasis is placed on techniques of image conversion and display processes utilizing microfilms. For individual titles, see N72-22169 through N72-22173.

N72-22169# Massachusetts Inst. of Tech., Cambridge. Electronic Systems Lab.
AN EXPERIMENTAL TEXT-ACCESS SYSTEM
Donald R. Knudson *In* AGARD Image Storage and Transmission Systems for the Dissemination of Inform. Feb. 1972 9 p refs Sponsored in part by NSF (See N72-22168 13-08)
Avail: NTIS

A system is described which was designed to provide remote access to 90,000 pages of microfilm storage. It is part of a computer-oriented model library for conducting user experiments with two types of library retrieval; one provides access to the computer-stored catalog data for a group of selected documents and the second provides access to the microfilmed text of those documents. The text-access system automatically retrieves, scans, and transmits requested pages to remote display terminals utilizing a wideband transmission network. The current system employs two types of image-storage devices: a direct-view storage tube and a photographic camera. The microfilm images are scanned by a flying-spot scanner, and the scan-line density and sweep rates are varied to accommodate the limitations imposed by the different display terminals. A single coaxial cable path links the terminals to each other and to the central scanning station. Video signals are preceded by encoded digital messages containing a terminal address and commands for controlling terminal functions. A combined catalog/text terminal was developed which displays either the digitally-encoded catalog data or the text video signal on the same cathode-ray tube. The text display electronics were added to a commercially available computer terminal utilizing a storage-tube display to provide access to both catalog and text from a single terminal. Author

N72-22170# Internationale Dokumentationsgesellschaft fuer Chemie m.b.H., Frankfurt am Main (West Germany).
COMPUTER AIDED INPUT OF GRAPHIC INFORMATION BY KEYBOARDING UNDER VISUAL CONTROL OF DISPLAY AS APPLIED TO CHEMICAL STRUCTURES
Hans-Stefan Neubert *In* AGARD Image Storage and Transmission Systems for the Dissemination of Inform. Feb. 1972 6 p (See N72-22168 13-08)
Avail: NTIS

A method is described, using computer supported keyboards with graphic displays, for processing and storing structural formulae of chemical compounds. By keyboarding the formula the graphic information is stored and the figure appears on the

screen where it can be verified visually and if necessary the input can be corrected. The proposed computer configuration allows the simultaneous input from 16 terminals. Author

N72-22171# National Physical Lab., Teddington (England). Information Systems Branch.
PACKET-SWITCHING NETWORK
D. L. A. Barber *In* AGARD Image Storage and Transmission Systems for the Dissemination of Inform. Feb. 1972 12 p refs (See N72-22168 13-08)
Avail: NTIS

High speed store-and-forward packet-switching techniques are proposed as an alternative to the use of the public telephone network by remote access computing systems. The type of traffic generated when computer systems react with human beings and with each other is examined, and it is shown why the use of the telephone network has drawbacks. Packet-switching is demonstrated to be more appropriate for handling such traffic, and some existing and projected packet-switching schemes are described. The effect these schemes may have on the development of future computing systems is considered, both in respect of computer and terminal development. Author

N72-22172# Philco-Ford Corp., Willowgrove, Pa.
PHOTOTRANSMISSION AND VIDEO STORAGE
Richard Schaphorst *In* AGARD Image Storage and Transmission Systems for the Dissemination of Inform. Feb. 1972 12 p refs (See N72-22168 13-08)
Avail: NTIS

Four advanced digital visual communication systems for transmitting animated television, single frame television, and facsimile are described in detail. The utilization of a video disc recorder for efficient storage of television images is discussed in application to the single frame TV system. The Digitel System designed for transmission over wideband circuits at 40 million bits/second provides high quality, fully animated color television service. The frame-to-frame Delta coding system operates at 16 million bits/second for digital transmission over conventional 5 MHz video circuits. The Vidicoder System stores TV pictures on a video disc recorder and provides for the digital transmission of a TV frame from one storage device to another up to 1 million bits/second. The Fastfax is a facsimile equipment which digitally transmits black/white and gray scale photographs over any communication channel up to 50 million bits/second. The four systems employ different picture coding and data compression techniques. DIGITEL employs two-bit Differential PCM; the Frame-to-Frame Delta System transmits brightness changes relative to a stored reference picture; the VIDICODER utilizes run length coding and bit plane coding; and the FASTFAX equipment employs run length coding and zero order interpolation processing. The relative performance and compression factors of these coding techniques are analyzed. Author

N72-22173# British Overseas Airways Corp., London (England).
PLANNING AND DEVELOPMENT OF COMPUTER OUTPUT ON MICROFILM FOR A COMMERCIAL APPLICATION
B. S. Harris *In* AGARD Image Storage and Transmission Systems for the Dissemination of Inform. Feb. 1972 8 p (See N72-22168 13-08)
Avail: NTIS

The computer/communications structure in a well-dispersed international organization are outlined, and a specific examination is made of the computer output to microfilm technique. The equipment used is described, principles of operation examined, and current and future applications discussed. Author

N73-24201# Advisory Group for Aerospace Research and Development, Paris (France)
GOVERNMENTAL ASSISTANCE FOR TECHNICAL INFORMATION IN INDUSTRY AND SIMPLE MECHANIZATION FOR SMALL INFORMATION CENTRES
Mar. 1973 99 p refs In ENGLISH partly in FRENCH Presented at the 25th Meeting of the AGARD Tech. Inform. Panel, Ankara, 23-24 Oct. 1972
(AGARD-CP-117) Avail: NTIS HC $7.00

The initiation and growth of small data centers and the problems of arranging them are summarized. Various forms and levels of information transfer to industry, from analysis and dissemination of summary reviews through visits to industry by technical information liaison personnel, to larger-scale nation wide dissemination to all interested firms, are discussed. For individual titles, see N73-24202 through N73-24212.

N73-24202 Advisory Group for Aerospace Research and Development, Paris (France)
INTRODUCTORY PAPERS: THE PRESENT STATE OF INFORMATION ACTIVITIES IN TURKEY AND FUTURE TRENDS
Kismet Burian (Scientific and Technical Research Council of Turkey) *In its* Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres Mar. 1973 4 p (For availability see N73-24201 15-08)

The state of the art of Turkey's information activities, as related to facilities and organizations of existing systems, are reported. Data are also given on TURDOK's role in designing a national information transfer system or network of systems to promote more effective and efficient execution of the national system. E.H.W.

N73-24203 SACLANT ASW Research Center, La Spezia (Italy)
ESTABLISHING SMALL INFORMATION CENTRES IN INDUSTRY
John P. Bethell *In* AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres Mar. 1973 7 p refs (For availability see N73-24201 15-08)

The function of a small information center in mediating between its community and the wider information network is explained, using the analogy of small medical centers. The differences between the information requirements of industry and those of science are emphasized and the desirability of clearly evaluating an industry's need for information before establishing an information center is indicated. Some of the specific duties of an industrial information center are described and it is stressed that these can now be most efficiently performed by requiring that the senior staff of the center have a broad education in information and its applications. It is recommended that the attitude of the center's staff and its organizational and physical location should be such as to maximize the center's orientation towards its users. Management is warned that some time must elapse before an information center becomes fully effective. Author

N73-24204 Royal Aircraft Establishment, Farnborough (England)
LIBRARY AND INFORMATION SERVICES AT THE ROYAL AIRCRAFT ESTABLISHMENT: SOME PROBLEMS AND THEIR PRESENT SOLUTIONS
R. C. Wright *In* AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres Mar. 1973 17 p (For availability see N73-24201 15-08)

Methods used to provide library and information services (more particularly information from books and journals) in a large research establishment (the services themselves being described in the Appendix) are outlined. Problems encountered in such an endeavor and present solutions to some of them are discussed. Author

N73-24205 Ministry of Education and Sciences, Documentation Department, The Hague (Netherlands)
TRAINING OF PERSONNEL TO MAN THE VARIOUS PARTS OF AN INFORMATION CENTRE AND TO OPERATE VARIOUS KINDS OF SERVICE
W. F. DeRegt *In* AGARD Governmental Assistance for Tech. Inform. in Ind. and Simple Mechanization for Small Inform. Centres Mar. 1972 4 p (For availability see N73-24201 15-08)

The problems and primary aims of training personnel or staff for an information center are outlined. Educational objectives

are formulated by which the sum total of attitudes, knowledge, and skills acquired by such personnel are defined. These objectives are also used to develop a suitable curriculum. Author

N73-24206 Rome Air Development Center, Griffiss AFB, N.Y.
MICROFORMS: PRESENT ECONOMICS AND FUTURE USE
Fred S. Dyer *In* AGARD Governmental Assistance for Tech. Inform in Ind and Simple Mechanization for Small Inform Centres Mar 1973 6 p refs (For availability see N73-24201 15-08)

Basic microforms and their integration with machine processing to achieve highly versatile information systems are analyzed. Costs and future use of the integrated system are also discussed. Author

N73-24207 Zentralstelle fuer Maschinelle Dokumentation (ZMD), Frankfurt (West Germany)
PROBLEMS OF DATA RECORDING AND DATA INTERCHANGE
Ruediger Bernhardt *In* AGARD Governmental Assistance for Tech Inform in Ind and Simple Mechanization for Small Inform. Centres Mar 1973 6 p refs (For availability see N73-24201 15-08)

Different data recording machines and their fonts of characters are outlined. Necessities and possibilities of structuring data are pointed out. Methods of checking and cleaning incorrect data are also mentioned. One of the possibilities of reducing the costs of data processing is the utilization of data interchange. Requirements concerning hardware and software for using interchange formats are explained. Author

N73-24208 Advisory Group for Aerospace Research and Development, Paris (France)
INPUT SYSTEMS AND RESEARCH FOR SMALL DOCUMENTARY CENTERS [SYSTEMES D'ENTREES ET DE RECHERCHES POUR DES CENTRES DOCUMENTAIRES DE FAIBLE OU MOYENNE IMPORTANCE]
J Kloop (CEDOCAR, Paris) *In its* Governmental Assistance for Tech Inform. in Ind and Simple Mechanization for Small Inform Centres Mar 1973 24 p refs In FRENCH (For availability see N73-24201 15-08)

Operating principles and types of data research centers are discussed. Data cover input systems, research format, data storage, automatic and mechanical research, and system classification. Transl. by E.H.W.

N73-24209 Defence Scientific Information Service, Ottawa (Ontario)
PRESENTING A DEVELOPMENT PLAN FOR APPROVAL
A C Jones *In* AGARD Governmental Assistance for Tech Inform. in Ind. and Simple Mechanization for Small Inform Centres Mar 1973 5 p refs (For availability see N73-24201 15-08)

The impact of various ways of presenting proposals for creating and developing a new information facility on higher management are reviewed. Some of the difficulties of establishing and presenting user needs are explored, and an analogy is offered on surveying of commodity marketing and salesmanship. Careful tailoring was made to the proposal to suit the management functions and facilitate evaluation. Suggestions are made on objective facility development and proposal merits. Author

N73-24210 Defence Research Information Centre, Orpington (England)
TAILORED ABSTRACTS AND TECHNICAL DIGESTS: A SERVICE FOR INDUSTRY
S C Schuler *In* AGARD Governmental Assistance for Tech Inform in Ind and Simple Mechanization for Small Inform Centres Mar 1973 9 p refs (For availability see N73-24201 15-08)

Three information services are described, each aiming to give a degree of selectivity in order to reduce the total amount of material a user must scan in order to obtain the information of use to him. The services are (a) the IEE Tailored Abstracts (TABs) which provide sections of the comprehensive IEE Abstracts journals as separate bulletins, (b) R and D Report Announcements issued by the UK DTI-TRC to give selective subject coverage in four separate bulletins derived from the comprehensive R and D Abstracts journal, and (c) the DTI Techlink service which provides one-page leaflets describing new materials, processes, techniques, etc., to individuals who have expressed an interest in the subject covered. The production and distribution of Techlinks are described in detail as the system can be used for the dissemination of various types of information. Author

N73-24211 National Research Council of Canada, Ottawa (Ontario)
INFORMATION EXTENSION SERVICES FOR INDUSTRY
Gerard Kirouac *In* AGARD Governmental Assistance for Tech. Inform. in Ind and Simple Mechanization for Small Inform. Centres Mar 1973 4 p (For availability see N73-24201 15-08)

A brief description is given of the experience of the Technical Information Service of the NRCC. Data emphasize the vital part of the liaison engineer in transferring technological information to small and medium scale industry through three sections of this service: the equity and answer division, the industrial engineering group and the technological development program. Improvements for the benefit of countries interested in this approach are suggested. Author

N73-24212* National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif
THE DEVELOPMENT AND USE OF A MODERN DATA BANK
Dudley G McConnell *In* AGARD Governmental Assistance for Tech Inform in Ind and Simple Mechanization for Small Inform Centres Mar 1973 8 p (For availability see N73-24201 15-08)
CSCL 09B

The modern data bank emphasizes immediate access by a user community which may be large in number, widespread, and having varied needs. Electronic computers have been found very useful in the processing of stored information. The key to the design of a data bank is the optimum mix of human intellectual effort and mechanized processing. The elements of the NASA data bank are presented as one approach to the many trade-off decisions involved in the development of a data bank and integrated information system. Author

N74-16925# Advisory Group for Aerospace Research and Development, Paris (France)
NEW DEVELOPMENTS IN STORAGE, RETRIEVAL AND DISSEMINATION OF AEROSPACE INFORMATION
Dec 1973 107 p refs Presented at 26th Meeting of the AGARD Tech Inform Panel London 2-3 Oct 1973
(AGARD CP 136) Avail NTIS HC $8.50

The state of the art in computerized processing of aerospace information is examined emphasizing mechanization developments with both large and minicomputers and in reprographics. For individual titles see N74-16926 through N74-16939.

N74-16926 Kingston-Upon-Hull City Libraries, Hull (England)
A COMPUTER PRODUCED KEYWORD INDEXING SYSTEM FOR TECHNICAL REPORTS IN THE LIBRARY OF THE AIRCRAFT RESEARCH ASSOCIATION LIMITED
Christopher Barnett *In* AGARD New Develop in Storage Retrieval and Dissemination of Aerospace Inform Dec 1973 7 p refs (For availability see N74-16925 08-08)

A computer produced cataloguing and subject indexing system for report material acquired by the ARA library is described. Keyword listings with indexes under authors and originators references are used to produce a monthly accession list and monthly and annual cumulating catalogues. The keywords are supplied manually using a specially constructed thesaurus. Author

N74-16927 Defence Scientific Information Service, Ottawa (Ontario) Processing and Publishing Div
A MINI COMPUTER BASED INFORMATION SYSTEM
R A McIvor *In* AGARD New Develop in Storage Retrieval and Dissemination of Aerospace Inform Dec 1973 7 p (For availability see N74-16925 08-08)

An automated information system is described based on two minicomputers, one of which is used for data input and the other for maintaining the master files and producing catalogue

cards, COM cartridges, KWOC indexes indexed document digests and SDI notices This production is more economical than an earlier system using a larger computer Author

N74-16928 European Space Research Organization, Paris (France)

AEROSPACE INFORMATION SERVICES: PROGRESS WITH THE ESRO-ELDO COMPUTERIZED INFORMATION NETWORK

N E C Isotta *In* AGARD New Develop. in Storage, Retrieval and Dissemination of Aerospace Inform Dec 1973 15 p refs (For availability see N74-16925 08-08)

The space documentation service is a joint organization of ESRO and ELDO Described is the present system in operation, the files available and proposed and probable short term developments within the next year and the possible future The present network is regarded as the forerunner of a completely distributed network with auxiliary and main nodes at strategic centers having a number of different minicomputer possibilities G G

N74-16929 Office for Scientific and Technical Information London (England)

THE ROLE OF OSTI IN INFORMATION RESEARCH AND DEVELOPMENT

John Gray *In* AGARD New Develop in Storage Retrieval and Dissemination of Aerospace Inform Dec 1973 3 p (For availability see N74-16925 08-08)

The contribution of OSTI to information research and development in the UK over 8 ½ 2 years of existence is assessed It is divided into four main sections - mechanized information systems information analysis centers, and general research and management research (including library automation) In each section an attempt is made to summarize the main purpose of stimulating and supporting research and the principles that guide support A concluding section deals briefly with support of research at Aslib and with the reviews of research in selected fields that OSTI has recently launched Author

N74-16930 Association of Special Libraries and Information Bureaux London (England)

CURRENT ASLIB RESEARCH ON MECHANISM

B C Vickery *In* AGARD New Develop in Storage Retrieval and Dissemination of Aerospace Inform Dec 1973 2 p refs (For availability see N74-16925 08-08)

An overview is given of the range of mechanization studies being carried out to explore the possibility of producing aerospace science abstracts by computer Apart from statistical computations computerized simulation of clerical processing in libraries is studied The use of machine readable records to generate an index for optical searching and data processing is emphasized G G

N74-16931 Transociates Ltd London (England)

EDUCATION AND TECHNICAL TRAINING FOR TECHNICAL INFORMATION

Felix Liebesny *In* AGARD New Develop in Storage Retrieval and Dissemination of Aerospace Inform Dec 1973 3 p refs (For availability see N74-16925 08-08)

The educational and training facilities in the United Kingdom for scientific and technical information workers and librarians are outlined with reference to the various levels of professional attainment The need for the training of teachers in these disciplines is stressed and some mention is made of forecast studies in supply and demand of information workers in the United Kingdom and the OECD countries Author

N74-16932 Greater London Council England

MICROFILM AND REPROGRAPHIC SYSTEMS: A STATE OF THE ART REVIEW

Thomas J Morgan *In* AGARD New Develop in Storage Retrieval and Dissemination of Aerospace Inform Dec 1973 5 p (For availability see N74-16925 08-08)

A review of the reprographic equipment and systems is presented that covers photocomposing systems computer output microfilming microform retrieval and display systems photo copiers and offset litho duplicating Author

N74-16933 Advisory Group for Aerospace Research and Development, Paris (France)

REMOTE TRANSMISSION AND AUTOMATED RETRIEVAL TECHNIQUES

R Barrett (Hatfield Polytechnic England) *In its* New Develop in Storage, Retrieval and Dissemination of Aerospace Inform Dec 1973 7 p (For availability see N74-16925 08-08)

Actual developments which have taken place in the field of automatic retrieval and remote display of full text information held in microform stores and prospects for future developments are discussed A feasibility study of remote access systems considers (1) information bank and storage medium, including the selector mechanism, (2) terminal equipment including technical and user acceptability aspects, (3) transmission system and (4) overall system economics Although the primary interest in this study is library automation, the techniques considered are equally applicable to other automatic retrieval and remote display fields Author

N74-16934 Naval Weapons Lab Dahlgren, Va Technical Information Div

RETRIEVAL OF MICROFICHE: RANDOM ACCESS

Cathryn C Lyon *In* AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform Dec 1973 7 p (For availability see N74-16925 08-08)

Three sizes of microfiche retrieval systems are discussed small medium and large that give random access to microfiche and film chips There are other random systems but they are usually set up for retrieval of microfilm This paper describes these systems and suggests indexing methods and index format for use with them It is intended to stimulate thinking about applications that are adaptable to the readers' collections Author

N74-16935 Defense Documentation Center, Alexandria Va

A MICROFICHE SYSTEM FOR SMALL USERS

Hubert E Sauter *In* AGARD New Develop in Storage Retrieval and Dissemination of Aerospace Inform Dec 1973 11 p refs (For availability see N74-16925 08-08)

Microfiche are particularly well suited to the reproduction, dissemination storage and retrieval of documents or records particularly those of 20 98 pages Since fiche are flat microforms they are easily retrieved and can be quickly duplicated for mailing or reference One of the major advantages of the microfiche is a possible savings of 70 percent or more in acquisition costs when a document is available in both microfiche and paper form Another advantage is the elimination of document storage problems, since low-cost copies of microfiche can be produced at any point on demand In many situations the most significant advantage is the savings in time and costs for packaging shipping storing and retrieving documents The equipment for small users for duplicating microfiche copies is quite inexpensive when compared to the cost of roll film machines Microfiche readers and reader printers are also considerably less expensive The economies achieved are primarily due to simple designs, containing few moving parts or motors Author

N74-16936 GEC Marconi Electronics Ltd Chelmsford (England) Research Labs

A COMPUTER-CONTROLLABLE ULTRAFICHE TERMINAL

F Duerden *In* AGARD New Develop in Storage Retrieval and Dissemination of Aerospace Inform Dec 1973 7 p (For availability see N74-16925 08-08)

The Automated Microform Terminal is a hardware contribution to the problem of cost effectiveness in computer aided learning, but the resultant specification was found to meet a need in information retrieval wherever the retrieval is from a large (say 200 000 pages upwards to many millions) or potentially large base via a computer searched index structure where a fast response is required to a specific enquiry The terminal exploits the high storage density handleability and low copy cost of 149 mm x 105 mm laminated ultrafiche (X 150 magnification) It has adequate precision to select and display any one out of 6000 individually addressable A5 pages from one fiche in 3 to 1 7 seconds under digital control either from computer or

keyboard The addition of a small magazine or cassette under development, with automatic fiche selection and capacity for 1/4 million pages, makes the system capacity virtually open ended Author

N74-16937 European Atomic Energy Community, Luxembourg
ABSTRACTS ON MICROFICHE FOR ON-LINE RETRIEVAL
Carl O Vernimb *In* AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform Dec 1973 13 p (For availability see N74-16925 08-08)

A short description of the characteristics of the European nuclear documentation service is given sources of information, structure of the thesaurus, file organization, retrieval strategy, system performance, and user behavior Three recent developments are described (1) Installation of a terminal for system/user dialog, direct access to part of the data base (200 000 documents) allows for query adjustment by evaluating the relevance of titles presented on the screen; the adjusted query formulation is applied to the total data base of 1 3 million documents, (2) installation of a microfiche reader-printer with a capacity of close to 300,000 abstracts, the abstracts are presented on a ground-glass screen within 4 seconds after keying in the corresponding reference numbers; and (3) introduction of a relevance feedback routine relevance decisions gathered when adjusting the query formulation are fed back into the computer together with the adjusted query, the descriptors are weighted according to their occurrence in relevant and irrelevant documents, the documents are ranked according to the sum of weights of their descriptors and printed out in order of decreasing probability Author

N74-16938 Mullard Research Labs , Salfords (England)
A RESEARCH WORKER'S VIEW ON THE FUTURE OF AUTOMATIC READING MACHINES
J A Weaver *In* AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform Dec 1973 8 p refs (For availability see N74-16925 08-08)

A general account of the justification for the use of automatic reading machines in a commercial data processing environment is presented A broad outline of the tasks of the component parts of a reading system is given, together with an indication of how modern reading machines are being made more cost effective than their predecessors A section is included on the recognition of handprinted material Future techniques which may increase the capability of reading machines whilst maintaining the current trend towards reducing size and cost are considered Optical character recognition has been in existence for several years - at a price It will become very widely used over the next few years as prices fall and data processing managers realize how to use the technique effectively Author

N74-16939 Hawker Siddeley Aviation, Ltd , Kingston upon Thames (England)
ALL CHANGE FOR AERONAUTICS
John E Allen *In* AGARD New Develop in Storage, Retrieval and Dissemination of Aerospace Inform Dec 1973 5 p (For availability see N74-16925 08-08)

The continuing patterns of changes in design, methods, subjects, fashion and major frameworks of reference have not only increased the volume of aerospace information but its complexity The information world has responded to this by evolving more and more sophisticated indexing languages, thesaurus classification and automated retrieval However, there is no consensus of opinion of a best way to proceed and as time goes on and first and second generation automatic systems come into use it will be increasingly difficult to introduce later methods because of the large capital replacement cost involved in such major changes Costs of complex information systems may become an unacceptable proportion of organisational activity Moreover such complexity and the existence of automatic systems may make too large demands on staff time, leaving less for consideration of the library/user interface Often, in aircraft design there are similar tendencies - advanced technology may give a somewhat better aircraft but often only at the expense of more cost, complexity, unreliability etc Good aeroplanes result from good design which is a strict discipline in avoiding unnecessary elaboration, complexity or cost In this sense a streamlining and avoidance of duplication, unnecessarily elaborate gadgets etc , may be advantageous Author

09 ELECTRONIC EQUIPMENT

Includes electronic test equipment and maintainability, component parts, e.g., electron tubes, tunnel diodes, transistors, integrated circuitry, microminiaturization. For basic research see 10 Electronics. For related information see also 07 Communications and 21 Navigation.

No abstracts in this subject category

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10 ELECTRONICS

Includes circuit theory, and feedback and control theory. For applications see 09 Electronic Equipment. For related information see specific Physics categories.

N74-13906# Advisory Group for Aerospace Research and Development, Paris (France)
COMPUTER AIDED DESIGN FOR ELECTRONIC CIRCUITS
Oct 1973 456 p refs Presented at 25th Tech Meeting on the Avionics Panel of AGARD, Lyngby, Denmark, 21-25 May 1973
(AGARD-CP-130) Avail NTIS HC $25.00

Conference papers are presented under the following headings (1) reliability, (2) modelling, (3) microwave, (4) analog, (5) digital, and (6) layout. For individual titles, see N74-13907 through N74-13938

N74-13907 Technical Univ of Denmark, Lyngby Institute of Circuit Theory and Telecommunication
THE TEACHING OF CACA IN DENMARK
Erik Lindberg *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 9 p refs (For availability see N74-13906 05-10)

Computer aided circuit analysis (CACA) is a central discipline in the area of computer aided design of electronic circuits (CADEC). Since 1969, 10 courses in CACA have been offered and attended by about 190 persons. Nevertheless it has turned out that apparently it is very difficult to introduce CACA in the industry. The implementation and use are considered, of a common accessible library containing a number of programs for general circuit analysis. Two programs, ANP3 and NAP2, for linear and nonlinear systems analysis, respectively, are reviewed in brief.
Author

N74-13908 Computer Aided Design Centre, Cambridge (England)
ECONOMICS OF CAD: A NEW APPROACH
A I Llewelyn and G C Freeman *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 10 p refs (For availability see N74-13906 05-10)

The economics of CAD is dependent on the degree to which commonalities can be recognised over a wide application front and embodied into common interactive software and a flexible computer system. The CAD Centre has worked closely with industry over the whole engineering front in order to identify such commonalities, while at the same time keying its development to industrial needs and operating in a commercial environment where the economics of CAD is always in the forefront. The Centre's function and facilities and its method of operation are described. The economic advantages to be gained from the use of a common system developed through experience gained by multi-organization multi-discipline working are discussed
Author

N74-13909 Admiralty Surface Weapons Establishment, Portsmouth (England)
RELIABILITY RELATED TO COMPUTER AIDED CIRCUIT DESIGN. A USER'S VIEW
N A Walter and A A Kaposi *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 10 p (For availability see N74-13906 05-10)

The problems of using computer aided circuit design in the reliability field are discussed and some of the possible reasons for the low utilization of computer aided circuit design are given. A method of simulating system reliability using computer aided circuit design type programs, is discussed and details given of such a method
Author

N74-13910 Radio Corp of America, Moorestown, N J Government and Commercial Systems Div
RELIABILITY AND COMPUTER AIDED DESIGN
James G Smith *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 11 p refs (For availability see N74-13906 05-10)

Information is presented to show that an integrated system of design aids raises the level of design assurance and thereby improves reliability. Topics of discussion include (1) reliability at the expense of design complexity, (2) pertinent attributes of the computer, (3) standard cell automation, (4) the standard cell library, (5) computer aided circuit design, (6) logic simulation and test generation, (7) computer aided printed circuit board design, and (8) backplane wiring design automation
D L G

N74-13911 Technical Univ of Denmark, Lyngby
COMPUTER AIDED DESIGN FOR MAXIMUM PRODUCTION YIELD OR MAXIMUM RELIABILITY
P W Becker and F Jensen (Storno A/S, Copenhagen, Denmark) *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 14 p refs (For availability see N74-13906 05-10)

The use of computer aided design is demonstrated as a means of optimizing electronic circuit or system production yield, or, ultimately, drift reliability. A mathematical model for the yield or drift reliability is introduced, and methods for numerical evaluation hereof are briefly reviewed. The unhappy task of assembling pertinent component data for the computations is also touched upon. Various optimization techniques suitable for the problem at hand are next commented upon, and finally the theory is put into use by optimizing the yield of two transistor circuits. The results and implications of the optimization are discussed
Author

N74-13912 Electronique Marcel Dassault, St Cloud (France)
COMPUTER AIDED DESIGN CONCEPTS [LA CONCEPTION DE PROJET ASSISTEE PAR ORDINATEUR]
J P Vedel *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 9 p In FRENCH (For availability see N74-13906 05-10)

A communication is presented on the use of computer concepts to aid in determining the reliability and costs of developing materials. The availability of the material was also considered
Trans. by E H W

N74-13913 Louvain Univ (Belgium)
THE USE OF THE TRANSISTOR SIMULATION PROGRAM SITCAP FOR STATISTICAL MODELING OF BIPOLAR TRANSISTORS
H Deman, R Merten, and H Grevens *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 11 p refs (For availability see N74-13906 05-10)

The program SITCAP is a simulator of bipolar transistors for computer aided circuit analysis. The main features of the program are its simple input-output structure and the new emitter model which is included in it. The main aspects of the program are described and examples are given of the application of the program for studying the statistical properties of bipolar transistors. It is demonstrated that in most cases the Gummel number must be taken as statistical variable, because the most important model parameters are correlated with it
Author

N74-13914 Norges Tekniske Hoegskole, Trondheim
TRANSISTOR EQUIVALENTS
O G Kjaerstad *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 12 p refs (For availability see N74-13906 05-10)

A method is presented to find the linear equivalent circuits of operational amplifiers and bipolar transistors. The method is general and the same method can be used to find the equivalent circuits of other components. The method is based upon using a CAD-program to minimize an error function by varying the component values of an equivalent circuit. The error function is derived from the difference between the computed response of the component, for example a transistor, and the known response. The known response can be the measured frequency response or derived from the manufacturer's data. The results of two projects are presented which include (1) operational amplifier

equivalent below 5 MHz. and (2) bipolar transistor equivalent below 30 MHz A project to find the equivalent circuit at higher frequencies is outlined Author

N74-13915 Advisory Group for Aerospace Research and Development, Paris (France)

AN OPTIMIZATION TECHNIQUE TO CALCULATE BIPOLAR TRANSISTOR PARAMETERS

Ronald J Covello (Ellsworth AFB, South Dakota) *In its* Computer Aided Design for Electron Circuits Oct 1973 12 p refs (For availability see N74-13906 05-10)

Presently, a severe problem exists in nonlinear network analysis Succinctly stated, this problem is that the measurement of the nonlinear parameters of bipolar transistors is time consuming, difficult, and costly An iterative computer technique is described for calculating these parameters using readily measured data The technique uses a two level optimization process Initially it assumes an arbitrary set of values for the parameters It then calculates transistor currents based on these parameters and measured voltages The calculated and measured currents are then compared and appropriate adjustments are made in the parameters This process is repeated till calculated and measured values of transistor currents agree At this time, the parameters are considered known Results are shown which demonstrate the validity and applicability of the technique Also, several minor modifications are suggested to optimize the process for production use Author

N74-13916 Elektronikcentralen Hoersholm (Denmark)

LINEAR TRANSISTOR MODELS IN HF NETWORK ANALYSIS. ADAPTION BETWEEN MEASUREMENTS AND ANALYSIS BY COMPUTER

P Stangerup *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 22 p refs (For availability see N74 13906 05-10)

It is demonstrated that the problem of including transistor data in linear analysis programs is easily overcome by means of a simple mathematical model This model can without difficulty be made to cover at least one decade at frequencies up to 1 GHz At the higher frequencies, the best representation of the transistor is the S-matrix Therefore it is desirable to make greater use of analysis programs based entirely on the S parameter representation Author

N74-13917 Advisory Group for Aerospace Research and Development Paris (France)

UNIT TRANSISTOR. MODEL OF BIPOLAR TRANSISTOR HAVING CONTINUOUS PARAMETERS AS THE GEOMETRIC DIMENSIONS [TRANSISTOR UNITE, MODELE DE TRANSISTOR BIPOLAIRE EN CONTINU AYANT COMME PARAMETRES LES DIMENSIONS GEOMETRIQUES DES TRANSISTORS]

P Leduc *In its* Computer Aided Design for Electron Circuits Oct 1973 14 p refs In FRENCH (For availability see N74 13906 05-10)

The addition of high level injection to IBIS transistor model and the effect of such an addition on continuous transistor functions are investigated The revised model is applied to the determination of parameters for two transistors A comparison was made of the measured and calculated gain and function of the collector circuit Transl by E H W

N74-13918 Siemens A G Munich (West Germany) Central Telecommunications Lab

STATE OF ART AND FUTURE TRENDS OF COMPUTER-AIDED DESIGN OF MICROWAVE INTEGRATED CIRCUITS

Hans-Norbert Toussaint and Reinmut Hoffmann *In* AGARD Computer Aided Design for Electron Circuits Jan 1973 14 p (For availability see N74-13906 05 10)

The future trend of MIC design will be to combine the previously separate CAD branches into one CAD system The hardware and software complement of this system is described The principal constituents of the software are a conversion program which permits the network to be calculated directly from the circuit layout, and a data bank in which the measured properties of special MIC components (e.g. transmission line discontinuities, lumped elements) are stored Author

N74-13919 Bell-Northern Research Ltd Ottawa (Ontario)

A COMPUTER PROGRAM FOR ANALYZING WAVEGUIDE STRUCTURES

Chuang-Jy Wu and Wayne Johnson *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 11 p refs (For availability see N74-13906 05-10)

A waveguide structure analysis program was developed in FORTRAN for implementation on an IBM 360/67 computer using the CP/CMS time sharing system From an input of mechanical dimensions, equivalent circuits of waveguide obstacles are generated by using previously published theoretical and/or experimental results Assuming that no evanescent mode interaction occurs between obstacles, an ABCD matrix manipulation is used to determine the overall network electrical response In addition, a classical waveguide filter design program, temperature and mechanical stability tests, and a tuning procedure have been provided to help solve day to day engineering problems Good agreement was obtained between measured and calculated results for waveguide transformers, and both bandpass and bandstop filters The program is essentially a piece of powerful design equipment with broadband capability and provides the designer with instant tabulated performance information for analysis Proper use of the program can save a considerable amount of model shop work and experimental effort in designing various types of waveguide networks Author

N74-13920 Servizio Meteorologico Italiano Milano

COMPUTER OPTIMISATION OF MICROWAVE INTEGRATED CIRCUITS DESIGN

S V Judd *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 8 p ref (For availability see N74 13906 05-10)

The design and implementation of a numerical optimization procedure are described suitable for realizing practical designs of hybrid microwave integrated circuits Considerable attention was given to achieving low running costs in terms of computation time, in order to make the methods described economically viable Author

N74-13921 Technische Hogeschool Delft (Netherlands) Microwave Lab

DAP (DISTRIBUTION ANALYSIS PROGRAM) A PROGRAM FOR THE ANALYSIS AND DESIGN OF MICROWAVE CIRCUITS

Joseph L Tauritz *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 23 p refs (For availability see N74-13906 05-10)

DAP is an easy to use computer program facilitating the analysis and design of microwave circuits employing lumped and distributed elements At present it has been in general use for over two years in the Microwave Laboratory of the Delft University of Technology DAP utilizes a modified chain matrix analysis scheme coupled to an extensive repertoire of microwave elements. Lumped and distributed elements such as resistors capacitors inductors, lossy transmission lines (both inline and stub) transformers, and arbitrarily specified ABCD matrices constitute the normal circuit elements The program s versatility is enhanced by the ease with which new element models may be added by the user The report includes an introduction to the mathematical basis of the program with emphasis on its more unusual aspects supplemented by a number of design examples The creation of special purpose element types to facilitate phase shifter transistor amplifier and parametric amplifier analysis are described A comparison with other presently available programs is made serving designers in several Canadian cities Author

N74-13922 Toulouse Univ (France)

MICROWAVE CIRCUIT ANALYSIS BY DIGITAL COMPUTER

C Vidallon *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 10 p refs (For availability see N74 13906 05 10)

The program ACLINE was conceived for the treatment in the frequency domain of the most general form of linear active networks with lumped and distributed elements (stubs, lines, coupled lines, circulators, etc) The components of the network may be described as black boxes, characterized by S, Y or Z parameters, and stored in a library with a code name It is also possible to use subnetworks, that are, after treatment, considered as conventional black-boxes Four types of controlled sources allow the optimum choice of active devices equivalent circuits A great number of results may be obtained from ACLINE, including all parameters or functions currently used to characterize linear networks performances in the frequency domain Sensitivities computation is made through two different methods For a check over a great number of components a general method is used A simple step-by-step optimization process may then be applied over a small number of sensitive parameters with a faster method (I A M) Sophisticated mathematical models of microwave active devices are also included in the program (avalanche diode for example) Author

N74-13923 Laboratoire Central de Recherches Thomson-CSF, Orsay (France)

SYTHESIS OF PASSIVE FILTERS WITH INFINITE ATTENUATION POINTS REALIZED WITH WEAK NOISE COMPONENTS APPLIED TO HIGH DEGREE CAUER FILTERS [SYNTHESE DE FILTRES PASSIFS A POINTES D'ATTENUATION INFINIES REALISES AVEC DES COMPOSANTS A FAIBLES PERTES APPLICATION AUX FILTRES DE CAUER DE DEGRE ELEVE]

C Gimenes *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 11 p refs In FRENCH (For availability see N74-13906 05-10)

Computer synthesis of filters as a function of attenuation frequency and transfer function was discussed After determining these functions the impedance overvoltage entering filter components terminal resistance, and transmission loss were determined Component values and filter schemes are included The functional characteristics of the filter were compared to those of high performance Cauer filters Transl by E H W

N74-13924 Societa Italiana Telecomunicazioni Siemens S p A , Milan (Italy)

COMPUTER DESIGN OF EQUAL RIPPLE EQUALIZATION

A Maggi and N Montelusco *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 8 p refs (For availability see N74-13906 05-10)

A digital computer program for automatic equalization of group-delay frequency characteristics is presented The program solves in the most general manner the problem of equal ripple equalization with a limited computation time and a reduced number of positions in computer memory The paper describes the iterative approximation process on a Newton Raphson basis An exhaustive analysis of the optimization and convergence of the procedure is also included Finally the actual computer program is illustrated and some practical results are given Author

N74-13925 Southampton Univ (England)

COMPUTER AIDED ANALYSIS OF ELECTRONIC CIRCUITS ON A SMALL MACHINE

K G Nichols *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 10 p refs (For availability see N74-13906 05-10)

The reasons are explained for commencing computer aided design activities on a small machine at Southampton University The cost of running the machine for this purpose is estimated Details of programs for small signal linear circuit ac analysis and non-linear circuit dc and transient analysis are given Examples of costs using these programs are included The problems associated with implementing analysis programs on small machines are briefly discussed Author

N74-13926 Philips Gloeilampenfabrieken N V Eindhoven (Netherlands) Research Labs

STRUCTURE AND APPLICATION OF COMPUTER PROGRAM ICAN INTEGRATED CIRCUIT AC ANALYSIS

E M VanderOuderaa *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 15 p refs (For availability see N74-13906 05-10)

The computer program ICAN (Integrated Circuit Analysis) is capable of calculating ac properties (small signal) of bipolar integrated circuits As input it needs technological data of the IC process geometrical data (from the layout) and nodal connections Details are given of the models used To get an indication of the accuracy of ICAN it is applied to a current mode logic gate in the frequency range 100-500 MHz The result is a reasonable agreement with measurements To improve this agreement use was made of a more accurate two-dimensional transistor model Author

N74-13927 Societe d'Etudes des Systemes d Automation Paris (France)

IMAG 2 ELECTRONIC CIRCUIT SIMULATIONS

Jean Arnould J P Sicot, and Claude LeFaou (INPG) *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 7 p refs (For availability see N74-13906 05-10)

IMAG 2 is a simulation program of linear or non-linear electronic circuits It allows the computation of the circuit's response under various conditions i e dc, ac, and transient analysis It also gives the sensitivity of one or several output variables according to one or several circuit components The program's use is simple and inexpensive because of the description's language and powerful calculation methods Author

N74-13928 Rockwell International Corp , Anaheim Calif

COMPUTER AIDED DESIGN ANALYSIS OF MODERN LARGE SCALE CIRCUITS AND SUBSYSTEMS

W Hochwald *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 41 p refs (For availability see N74-13906 05-10)

The SYSCAP (System of Circuit Analysis Programs) SELECT (System Evaluation of Large Scale Electronic Circuits and Transforms) family of computer programs ranks among the more powerful computer aids available to the design production reliability and logistics engineer As such, SYSCAP/SELECT encompasses proven technology in device modeling and mathematical structures while stressing ease of usage and economy Flexibility is provided to handle bipolar transistor electronics as well as MOS (Metal Oxide on Silicon) MSI/LSI (Medium and Large Scale Integrated) circuits on an individual basis, in hybrid configurations or in conjunction with functional system elements The capabilities user features, and options of SYSCAP SELECT are presented A circuit example and a control loop subsystem design example are given Theoretical background data are presented to substantiate the solution processes that are utilized Application areas where SYSCAP SELECT has proven to be cost effective are described with reference to the development cycle of complex modern electronic and electro-mechanical equipment Author

N74-13929 Bell Northern Research Ltd Ottawa (Ontario)

AN EVOLVING, OPERATIONAL COMPUTER AIDED DESIGN SYSTEM

G Scott, D L Williams, and L C Beaumont *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 12 p refs (For availability see N74-13906 05-10)

Computer graphics systems have not come into general use for computer aided design because of the high costs of both graphical hardware and graphical software The equipment cost has decreased but programming costs remain high A computer aided design system is described that uses a new high-level graphical language The development of the language and of the translator and other programs in the system are also described Some examples are given of applications using the language which is at present running on a large time sharing computer serving designers in several Canadian cities Author

N74-13930 Brunel Univ., Uxbridge (England)
SPECIFICATION AND DESIGN LANGUAGES FOR LOGIC SYSTEMS
Douglas Lewin *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 11 p refs (For availability see N74-13906 05-10)

The techniques are examined of representing logical processes in such a way that the resultant structures may be used both for the analysis and synthesis of the final system. The requirements for logic design languages are defined and current techniques are surveyed. The interactive design languages under development for the CALD system are described.
D L G

N74-13931* National Aeronautics and Space Administration Marshall Space Flight Center, Huntsville, Ala
THE NASA COMPUTER AIDED DESIGN AND TEST SYSTEM
J M Gould and K Juergensen *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 13 p refs (For availability see N74-13906 05-10)

A family of computer programs facilitating the design, layout evaluation, and testing of digital electronic circuitry is described. CADAT (computer aided design and test system) is intended for use by NASA and its contractors and is aimed predominantly at providing cost effective microelectronic subsystems based on custom designed metal oxide semiconductor (MOS) large scale integrated circuits (LSIC's). CADAT software can be easily adopted by installations with a wide variety of computer hardware configurations. Its structure permits ease of update to more powerful component programs and to newly emerging LSIC technologies. The components of the CADAT system are described stressing the interaction of programs rather than detail of coding or algorithms. The CADAT system provides computer aids to derive and document the design intent, includes powerful automatic layout software, permits detailed geometry checks and performance simulation based on mask data, and furnishes test pattern sequences for hardware testing.
Author

N74-13932 Societe Europeenne de Semiconducteurs et de Microelectronique, Paris (France)
SIGMA: AN INTEGRATED SYSTEM OF COMPUTER AIDED COMPLEX CIRCUIT DESIGNS [SIGMA: UN SYSTEME INTEGRE DE PROGRAMMES DE CONCEPTION ASSISTEE DES CIRCUITS COMPLEXES]
J P Lusinchi *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 25 p refs In FRENCH (For availability see N74-13906 05-10)

A detailed description is given of SIGMA a computer program designed to generate integrated and hybrid circuits. The program is divided into three parts: (1) IMAG 2T and PRIAM for analog simulation, (2) PSI for logical simulation and test sequence generation, and (3) GAMMA for diagram verification. Special circuits costs program applications are included.
Transl by E H W

N74-13933 Motorola, Inc., Phoenix, Ariz. Semiconductor Products Div
A COMPUTER AIDED DESIGN SYSTEM FOR LARGE SCALE INTEGRATED DIGITAL NETWORKS
R G Hamer and C S Meyer *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 11 p refs (For availability see N74-13906 05-10)

A CAD system presently being used in the design of LSI digital networks is described. Topics discussed cover logic system design and partitioning considerations, logic verification, circuit design, chip layout, and mask generation. Computer programs are described which aid the designer in logic simulation, fault detection, non-linear circuit analysis in dc and transient modes, routing of cell interconnect, and mask generation.
Author

N74-13934 REDAC Software Ltd., Tewkesbury (England)
COMPUTER AIDED DESIGN OF MULTILAYER PRINTED CIRCUIT BOARDS
W E Hillier *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 14 p refs (For availability see N74-13906 05-10)

The interactive computer layout of large multilayer printed circuit boards, including through via hole boards as well as buried via hole boards, is described. A full description of the software used is given together with details of the hardware and man machine interface. The system used is shown to be an extension of the internationally proven REDAC double sided P C B design package. The powerful software routines available for automatic routing and checking of the final layout are emphasized together with the ease with which the designer may interact with the program during its execution. It is shown that large layouts can be completed in a few weeks which would take a manual designer months to complete and would be very prone to manual designer error.
Author

N74-13935 International Computers Ltd., Manchester (England)
OPTIMISING AUTOMATIC TRACKING OF MULTILAYER BOARDS
H G Adshead *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 16 p refs (For availability see N74-13906 05-10)

The paper commences with a brief but critical appreciation of some known automatic tracking techniques for multilayer printed circuit boards, viz Maze-Running, Line-Search and Channel-Allocation. The purpose is to bring out their inherent similarity and to propound their specific superiority under different combinations of controlling criteria dictated by technological constraints. Consideration is given to the prohibitive core and time requirement for a real life environment involving an approximately 500 x 500 track matrix associated with the request for orthogonally connecting about 1500 pin pairs on each board. The evolution of an effective algorithm and list-structure capable of successfully handling this problem is discussed in detail. Several side issues of major significance are introduced. The efficient pre-sorting of the order in which wires are submitted to the main algorithm has been found to make a significant contribution to the efficiency of the entire system. Profile analysis is developed as a technique for comparing the relative merits of various topological placements of the logic network. The importance of the basic board layout and its relation to the algorithm employed is stressed.
Author

N74-13936 University of Southern Calif., Marina del Rey
A PARALLEL PRINTED CIRCUIT BOARD DESIGN SYSTEM
Donald R Oestreicher *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 12 p refs (For availability see N74-13906 05-10)
(Contract F30602-70-C-0300)

A unique approach is described for the automatic design of printed circuit boards in which all functions can be accomplished in parallel. Instead of producing the layout wire by wire as is currently the rule, the layout is produced by traversing the board in a raster scan fashion, routing all relevant wires in parallel. This allows all design functions to be accomplished simultaneously. The fact that the layout functions are done concurrently provides for greater feedback among the different functions and therefore greater efficiency, as more relevant information is available to each function. The algorithm also makes great use of the commutivities introduced by integrated circuits. This is done by unbinding the circuit into a structure which describes all possible pin assignments, as defined by the relevant commutivities. This structure then maintains this information as the layout algorithm makes decisions to bind particular pins to particular logical signals. The structure not only remembers past decisions but it also makes all derivative bindings required by the layout algorithm's decisions necessary to maintain the equivalence between the input circuit description and the actual implemented circuit.
Author

N74-13937 International Computers Ltd., Manchester (England) Microsystems Div
COMPUTER AIDED PLACEMENT AND ROUTING OF HIGH

DENSITY CHIP INTERCONNECTION SYSTEMS
N H Crocker, R W McGuffin, R Naylor, and H Vosper *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 26 p refs (For availability see N74-13906 05-10)

A novel approach to the problem of placement and interconnection of components is presented Conventional constraints, such as substrate or circuit board dimensions, are not considered at the outset, they are either absent or are suppressed until the stage is reached at which they are directly applicable The chosen approach was adopted to facilitate the placement and tracking of integrated circuit chips on a microwired array This form of construction, orthogonal tracks on either side of a dielectric layer connected by etched through-holes, has the advantage that the holes may be made within the width of a track The algorithms presented are technology independent and may be applied to any interconnection system which incorporates this feature Initially, the logic is placed on a continuous plane From this state, it is gradually transmuted through various cellular structures defined, initially by the components, and finally by a combination of the components and their associated tracks The culmination is an arrangement which, at all stages, is determined by the logic and not the technology Author

N74-13938 International Business Machines Corp., Owego, N Y

ERGONOMIC CONSIDERATIONS OF INFORMATION DISPLAY AND CONTROL FOR DESIGN AUTOMATION SYSTEMS
William M Gaddes *In* AGARD Computer Aided Design for Electron Circuits Oct 1973 13 p refs (For availability see N74-13906 05-10)

A method is described for ensuring that appropriate considerations be given to the requirements of the intended users during system development Trends in design automation systems are discussed, particularly with respect to the increased functional integration and interaction of the users with the system, as well as among multiple users A method is described, based on user-oriented flow diagrams, which is intended to define the user requirements A description is provided by which these diagrams are used to establish user requirements and to establish a communication link between the users and the system architects Difficulties that may be expected with regard to user interfaces are listed, and the value of the method for establishing ergonomic design and evaluation criteria, procedural aids and methods, and educational materials is discussed Author

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11 FACILITIES, RESEARCH AND SUPPORT

Includes airports, lunar and planetary bases including associated vehicles, ground support systems, related logistics, simulators, test facilities (e.g. rocket engine test stands, shock tubes, and wind tunnels), test ranges, and tracking stations.

N71-16060# Advisory Group for Aerospace Research and Development, Paris (France)
SIMULATION AGARD CONFERENCE PROCEEDINGS
Jan 1971 188 p refs AGARD Flight Mech Panel Specialists Symp held at Moffett Field Calif 10-13 Mar 1970
(AGARD CP-79-70) Avail NTIS
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3 FLIGHT SIMULATOR MATHEMATICAL MODELS IN AIRCRAFT DESIGN A H Lee (Boeing Co, Seattle, Wash) 23 p refs (See N71-16063 06-11)

4 MOTION VISUAL AND AURAL CUES IN PILOTED FLIGHT SIMULATION K J Staples (RAE Bedford Engl) 25 p refs (See N71-16064 06-11) 06-11)

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8 ENGINEERING ANALYSIS M Monfort (Centre d'Essais en Vol Istres France) 22 p refs (See N71-16068 06-11)

9 PILOT ASSESSMENT ASPECTS OF SIMULATION G E Cooper and F J Drinkwater, III (NASA Ames Res Center) 12 p refs (See N71-16069 06-11)

N71-16061# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany) Inst fuer Dynamik der Flugsysteme
SIMULATION AN INTRODUCTION AND SURVEY
Gerhard F Bruening *In* AGARD Simulation Jan 1971 18 p refs (See N71-16060 06-11)
Avail NTIS

A review is given on the state of the art of simulation. Linearized control theoretical aspects of simulation are discussed and examples of fixed base, moving base, and in-flight simulators are depicted with emphasis on the V/STOL problem. Ground simulators for environmental factors are analyzed with respect to motion, visual, and psychological parameters and methods for their simulation. The use of pilot opinion rating for evaluating simulation results is advocated. Differences between simulation on the ground and in the air are also outlined. G G

N71-16062# British Aircraft Corp, Preston (England)
OBJECTIVES OF SIMULATION
A G Barnes *In* AGARD Simulation Jan 1971 8 p (See N71-16060 06-11)
Avail NTIS

Simulations are used to (1) derive statements about properties of a system which may be read across to real situations, (2) provide a framework for the interpretation of experiments, (3) improve a model, and (4) suggest further experiments. Flight simulation experiments provide accelerated development of aircrafts at reduced costs by defining what is required in order to transfer results readily with increased confidence to the real situation and thus cut down on trial and error aspects G G

N71-16063# Boeing Co, Seattle, Wash
FLIGHT SIMULATOR MATHEMATICAL MODELS IN AIRCRAFT DESIGN
Alan H Lee *In* AGARD Simulation Jan 1971 23 p refs (See N71-16060 06-11)
Avail NTIS

Mathematical models are discussed from the viewpoint of a flight simulation user. Aerodynamic, flight control system, and atmospheric environment models are stressed. Some of their considerations are discussed relative to aircraft design phases. A quasi-elastic format for representing the aerodynamic characteristics of a large, flexible aircraft is described. It is shown that storing aerodynamic data in digital computers as split functions has advantages. Such items as controller feel, hysteresis, and actuator characteristics should be included in the flight control system mathematical model. Turbulence and wind shears are essential to any realistic simulation program. The von Karman power spectral density function is preferred for turbulence generations. Emperical wind shears are also useful Author

N71-16064# Royal Aircraft Establishment, Bedford (England)
MOTION, VISUAL AND AURAL CUES IN PILOTED FLIGHT SIMULATION
K J Staples *In* AGARD Simulation Jan 1971 25 p refs (See N71-16060 06-11)
Avail NTIS

The main characteristics of motion, visual and aural cues, are discussed for their integration into pilot flight simulation studies on variable stability aircraft. Areas of relevance and importance are defined for each of the cues and their interaction and substitution of one by another is considered. It is proposed that the principal attraction of simulation is speed and versatility in obtaining valid results for optimal man machine integration G G

N71-16065# Societe Nationale Industrielle Aerospatial, Toulouse (France)
COCKPIT ENVIRONMENT
Jean Pinet *In* AGARD Simulation Jan 1971 13 p refs (See N71-16060 06-11)
Avail NTIS

Various inputs of the simulation environment during Concorde cockpit development are considered. Computerized simulator trials started out with the variable stability Mirage 3B aircraft by considering external and internal visual displays, inertial perceptions and aural perception and verbal communications. Confrontation between simulation objectives and inputs and outputs of the crew members transfer functions with results from the various indices was used to define the environment simulation degree G G

N71-16066# National Research Council of Canada, Ottawa (Ontario)
SOME FACTORS INFLUENCING THE CHOICE OF A SIMULATOR
D M McGregor *In* AGARD Simulation Jan 1971 33 p refs (See N71-16060 06-11)
Avail NTIS

Some of the means by which the pilot derives motion information during flight and attempts to highlight some of the areas in which specific simulator characteristics are required to

obtain valid results are outlined Discussions of several shortcomings of present hardware that must be overcome before specific tasks, such as low altitude, low speed maneuvering flight, can be simulated adequately and the difficulties of achieving a thorough understanding of the man-machine system are presented Author

N71-16067# Cornell Aeronautical Lab, Inc Buffalo, N Y
THE SELECTION OF TASKS AND SUBJECTS OF FLIGHT SIMULATION EXPERIMENTS
Waldemar O Beuhaus and Robert P Harper Jr *In* AGARD Simulation Jan 1971 17 p (See N71-16060 06-11)
Avail NTIS

The limitations of various simulators directly affect the simulation tasks which can be performed and, hence, affect the validity of the evaluation results obtained The ability of simulator pilots to produce valid and repeatable evaluations which are applicable to the real world situation can be no better than the accuracy with which the simulator tasks represent the essential characteristics of the real world Certain considerations in the selection of simulator tasks are discussed, and problems are set forth which should be considered in the design of simulation experiments The selection and preparation of evaluation pilots are discussed in terms of the factors which appear to have substantial effects upon the program results Experience in the real-world mission is one of several key elements which greatly enchances the evaluation results Preparation of subjects considers the importance and nature of communication between the subject pilot and the analyst and participation of the subjects in the experimental design Author

N71-16068# Centre d'Essais en Vol, Istres (France)
ENGINEERING ANALYSIS
M Monfort *In* AGARD Simulation Jan 1971 22 p refs (See N71-16060 06-11)
Avail NTIS

The mixing of several simulation methods is advocated for engineering analyses on flight mechanics Emphasis is placed on analysis of the pilot's behavior for integration in the man-machine system by application of statistical and response surface techniques to both pilot ratings and pilot comments in measuring the pilot's workload G G

N71-16069*# National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif
PILOT ASSESSMENT ASPECTS OF SIMULATION
George E Cooper and Fred J Drinkwater III *In* AGARD Simulation Jan 1971 18 p refs (See N71-16060 06-11)
(NASA TM-X 66583) Avail NTIS CSCL 05H

Pilot assessment aspects of flight simulation consider the use of pilot ratings in the evaluation of aircraft handling qualities Critical questions raised by pilots are examined and discussed in order to develop solutions and improve understanding It is important to involve the pilot as early as possible in developing a piloted simulation program by considering complaints arising from simulation experiences as well as questions arising related to the pilot's actual participation in the planning and conducting of experiments the simulation facility and the analysis of results Author

N71-34263# Advisory Group for Aerospace Research and Development, Paris (France)
INVENTORY OF ACOUSTIC FATIGUE TEST FACILITIES IN THE NATO COUNTRIES
B L Clarkson (Southampton Univ) Jul 1971 15 p refs
(AGARD-R-584-71, AGARD-Rept 584) Avail NTIS

The acoustic test facilities for NATO are listed as of 1969 The characteristics of the noise generators including frequency range, sound levels, and typical spectrum provided are tabulated The instrumentation and data analysis systems are also tabulated for each facility. F.O S.

N72-12162# Advisory Group for Aerospace Research and Development, Paris (France)
FACILITIES AND TECHNIQUES FOR AERODYNAMIC TESTING AT TRANSONIC SPEEDS AND HIGH REYNOLDS NUMBER
R C Pankhurst Oct 1971 11 p refs
(AGARD-AR-37-71) Avail NTIS

Scale effects on various flow phenomena and for various body shapes are discussed Techniques are given for simulating the effects of higher Reynolds numbers The requirements and types of experimental facilities which can achieve high Reynolds numbers at transonic speeds are considered Author

N73-18260# Advisory Group for Aerospace Research and Development, Paris (France)
AERODYNAMIC TEST SIMULATION LESSONS FROM THE PAST AND FUTURE PROSPECTS
Julius Lukasiewicz, ed (Carleton Univ) Dec 1972 89 p refs Presented at AIAA 10th Aerospace Sci Meeting Panel Discussion, San Diego, Calif , 19 Jan 1972
(AGARD-R-603) Avail NTIS HC $6 50

Developments in aerodynamic test facilities used by government, university, and industry are discussed The following topics are reported (1) assessment of past experience, (2) present status and future prospects of aerodynamic and air breathing propulsion testing in all speed regimes, (3) ground test and flight comparisons, (4) free flight test techniques, and (5) the development of aerodynamic testing A review of the major West European wind tunnels and a discussion of aerodynamic test facilities in the United States are included in two appendices Author

N73-20269# Advisory Group for Aerospace Research and Development, Paris (France) Large Wind Tunnels Working Group.
THE NEED FOR LARGE WIND TUNNELS IN EUROPE
Dec. 1972 96 p refs
(AGARD-AR-60) Avail: NTIS HC $7.00

The Report of the Large Wind-Tunnels Working Group of the AGARD Fluid Dynamics Panels, follows nine meetings between December 1971 and November 1972 Review of existing position and future prospects, the role of the wind-tunnel in research and development, existing European wind-tunnels present national plans for wind-tunnels, future needs, options for new large low-speed and transonic tunnels, a proposed time schedule for provision of new tunnels, and proposals for a collaborative work program to clarify existing problems in wind-tunnel design and operation It is concluded that the first priority is for a new large pressurized transonic wind-tunnel in Europe, four possible options for realization of this need are given, and an Engineering Study is proposed, with a Work Statement, to assess and evaluate the engineering requirements of the options The second priority, of importance almost equal to the first, is for a new large low-speed wind-tunnel This should be of 18 m or 25 m width, the Group has not been able to agree between these figures Provision of new European supersonic and hypersonic facilities should begin when the subsonic and transonic requirements have been met, long term technical needs for these are defined Author

N73-26239# Advisory Group for Aerospace Research and Development, Paris (France)
PROBLEMS IN WIND TUNNEL TESTING TECHNIQUES
Apr 1973 165 p refs
(AGARD-R-601, AGARD-601) Avail NTIS HC $10 25

The design and operation of large wind tunnels for low speed and transonic speed conditions are described The subjects discussed include the following (1) methods for correcting wall constraints in transonic wind tunnels, (2) interference effects of model support systems, (3) minimum required measuring times

to perform instationary measurements in transonic tunnels, (4) wind tunnel requirements for helicopters, and (5) acoustic considerations for noise experiments at model scale in subsonic wind tunnels. For individual titles, see N73-26240 through N73-26247

N73-26240 Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
REVIEW OF SOME PROBLEMS RELATED TO THE DESIGN AND OPERATION OF LOW SPEED WIND TUNNELS FOR V/STOL TESTING
Mario Carbonaro *In* AGARD Probl in Wind Tunnel Testing Tech. Apr. 1973 24 p refs (For availability see N73-26239 17-11)
A review is made of a number of operational problems associated with the wind tunnel testing of V/STOL aircraft including helicopters. The following subjects are discussed (1) wall constraints, (2) use of ventilated walls, (3) testing for ground effect, and (4) flow disturbances in the tunnel circuit. Mathematical models are developed to clarify the theoretical aspects of wind tunnel operation. Author

N73-26241 Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France) Aerodynamics Dept
SURVEY OF METHODS FOR CORRECTING WALL CONSTRAINTS IN TRANSONIC WIND TUNNELS
Jean-Ch Vayssaire *In* AGARD Probl in Wind Tunnel Testing Tech Apr 1973 48 p refs (For availability see N73-26239 17-11)
The use of ventilated walls in transonic wind tunnels and the effect on wall interference corrections are discussed. Mathematical applications of the extreme cases of zero permeability and infinite permeability are examined. The solutions are compared and the characteristics of theoretical working sections are analyzed. Mathematical models are provided to support the theoretical considerations. Author

N73-26242 Aircraft Research Association, Ltd , Bedford (England)
INTERFERENCE EFFECTS OF MODEL SUPPORT SYSTEMS
E C Carter *In* AGARD Probl in Wind Tunnel Testing Tech Apr 1973 10 p refs (For availability see N73-26239 17-11)
The forms of interference occurring in subsonic and transonic wind tunnels due to model support systems are discussed. Two types of model attachment, rear sting and vertical blade sting are considered and the form and magnitude of interference terms are given for some particular examples. The buoyancy interference in the working section due to a typical sting joint and roll mechanism behind a model is considered and the effect on drag is evaluated for two typical bodies Author

N73-26243 Nationaal Lucht-en Ruimtevaartlaboratorium, Amsterdam (Netherlands)
MINIMUM REQUIRED MEASURING TIMES TO PERFORM INSTATIONARY MEASUREMENTS IN TRANSONIC WIND TUNNELS
J W G VanNunen, G Coupry (ONERA, Chatillon-sous-Bagneux, France), and H Foersching (DFVLR, Goettingen, West Germany) *In* AGARD Probl in Wind Tunnel Testing Tech Apr 1973 2 p refs (For availability see N73-26239 17-11)
The minimum required run times for instationary measurements at transonic speeds during wind tunnel tests are analyzed. The subjects discussed are (1) instationary pressure measurement techniques, (2) flutter tests, (3) buffet measurements, and (4) cross correlation techniques. It is concluded that present test methods require a minimum running time of ten seconds. It is suggested that new test techniques may reduce the time requirement Author

N73-26244 Royal Aircraft Establishment, Bedford (England)
SOME CONSIDERATIONS OF TESTS UNDER DYNAMIC CONDITIONS IN LOW SPEED WIND TUNNELS
D N Foster *In* AGARD Probl in Wind Tunnel Testing Tech Apr 1973 4 p refs (For availability see N73-26239 17-11)
The objectives of dynamic tests conducted in low speed wind tunnels are examined. For a number of specific problems for measurements under static conditions it is possible that special techniques and new equipment will be required. The two general areas of consideration are (1) measurement of oscillatory derivatives and (2) measurement of transient motions caused by gusts and ground effect. It is concluded that the main requirements for data relevant to dynamic effects can be met under static conditions over a wide range of variables Author

N73-26245 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Aerodynamische Versuchsanstalt
USE OF MODEL ENGINES (V/S/CTOL)
E Melzer and R Wulf *In* AGARD Probl in Wind Tunnel Testing Tech Apr 1973 17 p refs (For availability see N73-26239 17-11)
The special conditions required to conduct wind tunnel tests of jet aircraft engines are examined. The capabilities for simulation in atmospheric tunnels are discussed. The problems of testing in pressurized tunnels are analyzed. An estimation of the energy, the plants, and the test equipment required for engine simulation are listed Author

N73-26246 Westland Helicopters, Ltd , Yeovil (England)
WIND TUNNEL REQUIREMENTS FOR HELICOPTERS
I A Simons and H Derschmidt (MBB, Munich) *In* AGARD Probl in Wind Tunnel Testing Tech Apr 1973 10 p refs (For availability see N73-26239 17-11)
The sizes of model which are most suited to various aspects of wind tunnel tests of helicopters are defined. The scaling laws and associated constructional problems of small scale rotor systems are discussed. Tunnel sizes are suggested for various ranges of model size based on a consideration of interference effects Author

N73-26247 Royal Aircraft Establishment, Farnborough (England) Aerodynamics Dept
ACOUSTIC CONSIDERATIONS FOR NOISE EXPERIMENTS AT MODEL SCALE IN SUBSONIC WIND TUNNELS
T A Holbeche and J Williams *In* AGARD Probl in Wind Tunnel Testing Tech Apr 1973 30 p refs (For availability see N73-26239 17-11)
Acoustic considerations for noise experiments at model scale in subsonic wind tunnels are presented. Emphasis is placed on similarity to flight test conditions, noise measurement constraints on model and tunnel sizes, the parasitic effects of background noise, and the various factors contributing to the generation of noise. The specific contributions to tunnel noise from the tunnel drive fan, the tunnel circuit, the test section mainstream flow, and the particular test section boundary conditions are discussed Author

N74-16987# Advisory Group for Aerospace Research and Development, Paris (France)
PROBLEMS OF WIND TUNNEL DESIGN AND TESTING
Dec 1973 179 p refs Mostly in ENGLISH, partly in FRENCH
(AGARD R 600) Avail NTIS HC $12.00
The design and operation of low speed and transonic wind tunnel are discussed. Emphasis is placed on possible future large wind tunnels for Europe. The subjects discussed are (1) transonic Ludwieg tube wind tunnel (2) system for generation of quiet transonic flows for model testing at high Reynolds number (3) the injector driven wind tunnel, and (4) facilities for aerodynamic testing at hypersonic speed. For individual titles, see N74-16988 through N74-16993

N74-16988 Royal Aircraft Establishment, Farnborough (England)
SOME CONSIDERATIONS OF FUTURE LOW-SPEED TUNNELS FOR EUROPE
A Spence and B M Spee (Natl Aero- and Astronaut Res Inst, Amsterdam) *In* AGARD Probl of Wind Tunnel Design and Testing Dec 1973 10 p Prepared in cooperation with

Natl Aero- and Astronaut Res Inst, Amsterdam (For availability see N74-16987 08-11)

Two series of possible future low-speed windtunnels have been studied The first series are high-Reynolds-number tunnels having a product of working section width in metres and maximum pressure in atmospheres kept constant at a value of 45, but including in addition a 60m atmospheric tunnel The second series comprises atmospheric tunnels of widths ranging from 8m to 25m, and these are of more modest cost and generally lower capability than the first series Very broad estimates of possible capital and running costs are given as an indication of the scale of expenditure which might be involved, no precise quotations have been obtained Brief statements are made of the capabilities of the tunnels considered Each series in turn appears to offer attractive possibilities for future provision of low speed tunnels in Europe Author

N74-16989 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany) Inst fuer Stroemungsmechanik

PROJECT STUDY OF A LARGE EUROPEAN TRANSONIC LUDWIEG TUBE WINDTUNNEL

H Ludwieg, H Grauer-Carstensen, and W Lorenz-Meyer *In* AGARD Probl of Wind Tunnel Design and Testing Dec 1973 22 p refs (For availability see N74-16987 08-11)

A study of a transonic Ludwieg Tube wind tunnel is presented For a reliable extrapolation of windtunnel measurements to full-scale flight conditions of modern aircraft, a realistic simulation of flight Reynolds numbers at transonic speeds becomes increasingly important It is shown, how the need for a high Reynolds number experimental facitity can be satisfied by a Ludwieg Tube tunnel The Ludwieg Tube is characterized by its unsurpassed simplicity which guarantees a high degree of reliability Design data, dimensions, and cost estimates for the described tube wind tunnel are presented The basic facility characteristics are given Author

N74-16990 Royal Aircraft Establishment, Bedford (England)

THE DEVELOPMENT OF AN EFFICIENT AND ECONOMICAL SYSTEM FOR THE GENERATION OF QUIET TRANSONIC FLOWS SUITABLE FOR MODEL TESTING AT HIGH REYNOLDS NUMBER

P G Pugh *In* AGARD Probl of Wind Tunnel Design and Testing Dec 1973 17 p refs (For availability see N74-16987 08-11)

Current work on the development of the ECT drive system is reviewed It is shown that this is a particularly economical and effective means of providing a radical improvement in the Reynolds numbers at which transonic, wind-tunnel tests can be performed Experimental trails which confirmed the practicability of the essential features of this system are described, and the problems of optimizing the design of a particular wind-tunnel are discussed Author

N74-16991 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

THE INJECTOR DRIVEN TUNNEL

Pierre Carriere *In* AGARD Probl of Wind Tunnel Design and Testing Dec 1973 56 p refs (For availability see N74-16987 08-11)

The development and characteristics of an injector driven wind tunnel are described The subjects discussed are (1) methods for evaluating and optimizing the performance in steady continuous flow, (2) analysis of unsteady phenomena during the wind tunnel start, and (3) problems of intense noise generated by the jets Indications on the orders of magnitude of basic technological data Sketches of the active part of the induction driven tunnel and a graph of the thermodynamic cycle are presented Author

N74-16992 Institut Aerotechnique de Saint-Cyr, Saint-Cyr-l'Ecole (France)

HYDRAULIC COMPRESSOR WIND TUNNEL [SOUFFLERIE A COMPRESSEUR HYDRAULIQUE]

Maurice Menard and Francis Chometon *In* AGARD Probl of Wind Tunnel Design and Testing Dec 1973 28 p refs In FRENCH (For availability see N74-16987 08-11)

A description is given of a motor system for transonic wind tunnels with large Reynolds numbers The installation and its functions were also described Theoretical studies were made of thermodynamic cycles based on the possible evolution of power absorbed by the installation Data are also given on the economics of the wind tunnel project, technological solutions proposed, and proper reservoir construction Transl by E H W

N74-16993 National Aerospace Lab, Amsterdam (Netherlands)

FACILITIES FOR AERODYNAMIC TESTING AT HYPERSONIC SPEEDS

F Jaarsma and W B DeWolf *In* AGARD Probl of Wind Tunnel Design and Testing Dec 1973 40 p refs (For availability see N74-16987 08-11)

An assessment is made of the usefulness and potential of existing European hypersonic facilities, on the basis of the planned U S space shuttle project and a hypothetical hypersonic transport aircraft With respect to aerodynamic testing of space shuttle type of vehicles it is pointed out that a significant gap exists between M ≈ 10 and M ≈ 15 At low-hypersonic Mach numbers the facilities in Europe will generally meet the minimum requirements for testing hypersonic transport models European capabilities appear to be rather similar to those in the U S hypersonic wind tunnels, though the U S capabilities will be increased considerably in the near future It is further concluded that European facilities fall short in their performance of what is required, in the field of propulsion (including supersonic combustion tests) and also of hardware testing Author

12 FLUID MECHANICS

Includes boundary-layer flow, compressible flow, gas dynamics, hydrodynamics, and turbulence. For related information see also 01 Aerodynamics, and 33 Thermodynamics and Combustion.

N71-25073# Advisory Group for Aerospace Research and Development, Paris (France)
REPORT OF THE HIGH REYNOLDS NUMBER WIND TUNNEL STUDY GROUP OF THE FLUID DYNAMICS PANEL
Apr 1971 24 p refs
(AGARD-AR-35-71) Avail NTIS

The working group considered transonic wind tunnel performance and operating characteristics required to support evolution of military and civil aeronautical and aerospace systems during the coming decade. These considerations along with a review of experience on model testing at transonic speeds led to the conclusion that the NATO nations should acquire, as soon as possible, two types of new wind tunnels. One tunnel should duplicate transonic flight Reynolds numbers and have a run time on the order of one second. The second should have a 16 ft test section and should provide Reynolds numbers that are 3 or 4 times the maximum presently available with a run time on the order of 10 seconds. It was also concluded that AGARD should support current research and development in design, operation and test techniques in transonic tunnels of the continuous, conventional blowdown and Ludwieg tube type, and that AGARD should encourage expansion of these activities in the future. Author

N72-15269# Advisory Group for Aerospace Research and Development, Paris (France).
TABLES OF INVISCID SUPERSONIC FLOW ABOUT CIRCULAR CONES AT INCIDENCE, GAMMA EQUALS 1.4, PART 3
D. J. Jones (Natl Aeron Estab, Ottawa Ontario) and W. J. Rainbird, ed (Carleton Univ) Dec 1971 172 p refs
(AGARDograph-137-PT-3; AGARD-AG-137-71-PT-3; UDC-533.696.4:533.6.011.5:083) Avail NTIS

Tabulated results are presented for half cone angles of 45, 47.5, 50, 52.5, and 57 degrees with Mach numbers ranging from 3 to 20. Author

N72-20273# Advisory Group for Aerospace Research and Development, Paris (France)
TURBULENT SHEAR FLOWS
Jan 1972 506 p refs Presented at the Fluid Dyn Panel Specialists Meeting, London, 13-15 Sep 1971
(AGARD-CP-93) Avail NTIS HC $6.00 MF $0.95

Turbulent shear flows such as boundary layers, jets, and wakes, were investigated for nonreacting gas flow. Factors considered were the basic structure of equilibrium shear flows and the influence of compressibility, pressure gradients, surface curvature, three-dimensional flows, noise, density, and/or temperature gradients. For individual titles, see N72-20274 through N72-20307.

N72-20274# Imperial Coll of Science and Technology, London (England) Dept of Aeronautics
VARIATIONS ON A THEME OF PRANDTL
Peter Bradshaw *In* AGARD Turbulent Shear Flows Jan 1972 10 p refs (See N72-20273 11-12)
Avail NTIS HC $6.00 MF $0.95

Varieties of complex turbulent flow which are important in engineering are recognized as perturbations of classical thin shear layers to which Prandtl's approximation applies. The types distinguished are: (1) shear layers, (2) shear layers perturbed by small additional strain rates which produce appreciable changes in turbulence, and (3) shear layers perturbed by large additional strain rates. Examples are airfoil boundary layers merging into a wake, boundary layers on curved surfaces, and reattaching shear layers. The essential phenomena of these turbulent flows are discussed, and it is concluded that a program of turbulence measurement should enable calculation methods to be extended to a wide range of complex flows. A discussion of the general types of calculation methods suitable for complex flows is included. Author

N72-20275# Michigan Univ., Ann Arbor. Dept of Aerospace Engineering
STRUCTURE OF THE REYNOLDS STRESS NEAR THE WALL
W. W. Willmarth and S. S. Lu *In* AGARD Turbulent Shear Flows Jan 1972 20 p refs (See N72-20273 11-12)
(Contract N00014-67-A-0181-0015)
Avail NTIS HC $6.00/MF $0.95

Experimental studies are reported on the flow field near the wall in a turbulent boundary layer using hot wire probes. Measurements of the product uv were made using conditional sampling and with the aid of a digital computer. The criterion used to determine when uv was to be sampled was when streamwise velocity at the edge of the sublayer had attained a certain value. It was found that 60% of the contribution to uv occurred when the sublayer velocity was lower than mean velocity. Measurements involving correlation of truncated u and v signals revealed that the largest portion of Reynolds stress and turbulent energy components occurs when u < 0, v > 0, or during an intense bursting process, the remainder occur during recovery. Contributions to the production of turbulence and Reynolds stress at a point near the wall are of large magnitude, short duration, and intermittent. A rough measure of the intermittency factor for uv is 0.55. Author

N72-20276# Aix-Marseilles Univ (France) Inst de Mecanique Statistique de la Turbulence
SPECTRAL DISTRIBUTIONS OF THERMAL FLUCTUATIONS IN A TURBULENT BOUNDARY LAYER [REPARTITIONS SPECTRALES DES FLUCTUATIONS THERMIQUES DANS UNE COUCHE LIMITE TURBULENTE]
L. Fulachier and R. Dumas *In* AGARD Turbulent Shear Flows Jan 1972 10 p refs In FRENCH, ENGLISH summary (See N72-20273 11-12)
Avail NTIS HC $6.00/MF $0.95

Temperature fluctuation spectra and spectral distributions of temperature velocity were measured in a turbulent boundary layer on a heated flat plate. The method of fluctuation diagramming was used for frequency-filtered signals in order to measure spectral correlation distribution. A comparison of thermal spectra and three velocity components is presented from the internal zone as far as the edge of the boundary layer. Balance equations are given for spectral distributions relative to temperature and the sum Q(n) for the spectra of the velocity components. Spectral distributions of production terms and molecular dissipation are also considered. Author

N72-20277# University of Southern Calif., Los Angeles. Dept of Aerospace Engineering
INTERMITTENT STRUCTURES IN TURBULENT BOUNDARY LAYERS
R. F. Blackwelder and R. E. Kaplan *In* AGARD Turbulent Shear Flows Jan 1972 7 p refs (See N72-20273 11-12)
(Grants NSF GK-24578; NSF GK-27800)
Avail NTIS HC $6.00 MF $0.95

The intermittent structure in the outer region and the occurrence of intermittent bursts near the wall were investigated. The extent of these structures is characterized by the existence of streamwise momentum defects. Correlations suggest a connection between bursting that occurs in the wall region and the intermittent bulges of turbulence that protrude from the

outer reaches of the turbulent boundary layer A scheme is presented for the detection of turbulent bursts near the wall. Conditional averaging showed that during the burst there was a substantial streamwise momentum defect followed by an extremely rapid acceleration The measurements suggest that perhaps a local instability is the source of the break-up of the wall flow. Author

N72-20278# Technische Univ., Berlin (West Germany) Inst. fuer Ueberschall Technik.
AN INTEGRAL METHOD FOR APPROXIMATE CALCULATION OF COMPRESSIBLE TURBULENT BOUNDARY LAYERS WITH STREAMWISE PRESSURE GRADIENT
H.-J Kuester *In* AGARD Turbulent Shear Flows Jan 1972 20 p refs (See N72-20273 11-12)
Avail NTIS HC $6.00/MF $0.95

An approach is presented for the transformation function sigma sub x which avoids both sublayer and substructure hypotheses of compressible turbulent boundary layers Agreement between theory and experiment was obtained using a modification of skin friction principles Thermodynamic behavior is approximately described by a modified Crocco integral which accounts for non-unit Prandtl number, and variable pressure and/or wall temperature The boundary layer parameters of the transformed flow were calculated by a method based on the integral equations for momentum and mechanical energy The calculation method was applied to a variety of turbulent boundary layers with and without pressure gradient Author

N72-20279# Rhode Island Univ., Kingston
A SIMPLE ANALYSIS OF TWO DIMENSIONAL TURBULENT SKIN FRICTION WITH ARBITRARY WALL AND FREE-STREAM CONDITIONS
Frank M White and George H Christoph *In* AGARD Turbulent Shear Flows Jan 1972 10 p refs Supported by the AF (See N72-20273 11-12)
Avail NTIS HC $6.00/MF $0.95

An approach is proposed for an approximate analysis of the two-dimensional turbulent boundary layer under a wide variety of arbitrary conditions An effective formula is developed for the law-of-the wall which accounts for all of the different parameters considered The wall law is combined with the differential momentum equation into a single first-order ordinary differential equation for the skin friction coefficient, suitable for computer or graphical solution and, in special cases, closed form solutions. Examples are given covering combinations of eight different effects pressure gradient, heat transfer, compressibility, roughness, wall transpiration, transverse curvature, longitudinal curvature, and aqueous polymer solutions The results indicate that the theory is not only the simplest existing analysis of the turbulent boundary layer but one of the most accurate Author

N72-20280# Karlsruhe Univ. (West Germany)
AN EDDY VISCOSITY BASED ON THE SECOND PRINCIPAL INVARIANT OF THE DEFORMATION TENSOR
Willi Schoenauer *In* AGARD Turbulent Shear Flows Jan 1972 10 p refs (See N72-20273 11-12)
Avail NTIS HC $6.00/MF $0.95

Equations were derived for the time mean values of incompressible turbulent flow The stress tensor was considered to be a function of the deformation tensor. The assumption of spatial homogenity and isotropy led to eddy viscosity dependence on the second principal invariant of the deformation tensor The eddy viscosity function contains empirical coefficients which must be determined from measurements of turbulent equilibrium flows Nonequilibrium flows were then described by relaxation equations Equations for the turbulent boundary layer were derived The empirical coefficients of the eddy viscosity function were determined for flat plate flow Author

N72-20281*# Virginia Polytechnic Inst., Blacksburg. Dept. of Aerospace Engineering.
EFFECTS OF STRONG AXIAL PRESSURE GRADIENTS ON TURBULENT BOUNDARY LAYER FLOWS
Clark H Lewis, E. W Miner, and E C Anderson *In* AGARD Turbulent Shear Flows Jan. 1972 14 p refs (See N72-20273 11-12)
(Contract NAS1-9337)
(NASA-CR-125903) Avail: NTIS CSCL 20D

Comparisons are made between predictions for nonreacting turbulent boundary layer flow using a finite difference method, and integral methods used to predict compressible turbulent flows with pressure gradient and wall heat transfer. Both rocket and hypersonic aerodynamic wind tunnel nozzles are considered. Cooled and heated walls were studied Van Dries and Reichardt's models were considered in a two-layer eddy viscosity scheme Under heated wall conditions (i.e. wall temperature greater than the adiabatic wall temperature), strong coupling effects were found between wall heating and axial pressure gradients. For cooled wall conditions, predictions of velocity and temperature profiles downstream from regions of strong favorable pressure gradients were in good agreement with limited experimental profile data. Limitations in the use of boundary layer transformations for heated wall flows are presented. A computer program was developed to predict nonreacting and equilibrium chemically reacting laminar and/or turbulent boundary layer flows for internal (nozzle) and external two-dimensional and axisymmetric flows. Author

N72-20282# Instituto Superior Tecnico, Lisbon (Portugal).
MACH NUMBER EFFECTS IN TURBULENT FLOW
J. J. D. Domingos *In* AGARD Turbulent Shear Flows Jan. 1972 10 p refs (See N72-20273 11-12)
Avail NTIS HC $6.00/MF $0.95

Starting from fundamental assumptions of microscopic thermodynamics and continuum mechanics, the existence of a velocity potential for the flow of viscous fluids was proved as a general property. The implications are discussed and the role of compressibility as an essential feature of turbulence, either in subsonic or supersonic flows, is stressed The apparently contradictory consequence of zero vorticity in flows which are derived from a potential is clarified through a discussion of concepts implicitly assumed in the usual definitions of mean density, mean velocity, and thermodynamic equations of state. The results are applicable to general supersonic viscous flows, because the theory is concerned with instantaneous velocity fields, without separation into mean and turbulent quantities. The solutions found are asymptotically exact solutions of the time-dependent three-dimensional Navier-Stokes equations for a viscous and compressible fluid which follows a polytropic evolution. Author

N72-20283# Avco Corp., Wilmington, Mass Avco Systems Div.
A TWO LAYER MODEL OF HIGH SPEED, THREE DIMENSIONAL TURBULENT BOUNDARY LAYERS AND SUPERCRITICAL BOUNDARY LAYER INVISCID FLOW INTERACTIONS
Barry L Reeves *In* AGARD Turbulent Shear Flows Jan 1972 21 p refs (See N72-20273 11-12)
Avail NTIS HC $6.00/MF $0.95

A two-layer model of the three-dimensional compressible turbulent boundary layer was developed which is applicable to flows with pressure gradient and surface mass transfer The model is based on the small cross flow approximation in which the spreading metric is determined by the inviscid streamline pattern A modified Mangler transformation was employed which permits transformation of the boundary layer equations to a two-dimensional form without transforming the turbulent stress or heat flux The computational speed of the method is rapid enough to enable equations for the inviscid stream deflection to be coupled with method used for calculations of strong (supercritical) interactions, such as in the region downstream of the critical point in reattaching flows or in regions of strong

blowing. Solution of the inner (wall) layer for the velocity, enthalpy, stress and heat flux was obtained using mixing length theory and the thin layer Couette model. This solution led to a generalized compressible law of the wall with mass injection. In the outer wake layer an integral moment method was used along with appropriate matching conditions with the inner layer. Several solutions and experimental comparisons are presented. Results are also presented for relaxing flows where C sub f and (2C sub H)/C sub f initially are far from their equilibrium values.
Author

N72-20284# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
APPLICATION OF AN IMPROVED MIXING LENGTH MODEL TO THE STUDY OF THREE DIMENSIONAL BOUNDARY LAYERS [APPLICATION D'UN SCHEMA AMELIORE DE LONGUEUR DE MELANGE A L'ETUDE DES COUCHES LIMITES TURBULENTES TRIDIMENSIONNELLES]
J. Cousteix, C. Quemard, and R. Michel *In* AGARD Turbulent Shear Flows Jan. 1972 11 p refs In FRENCH; ENGLISH summary (See N72-20273 11-12)
Avail: NTIS HC $6.00/MF $0.95

An improved mixing-length model, previously applied to two-dimensional flow, is extended to cover the three-dimensional case, relying on the assumption that the turbulent shear stress acts in the same direction as the laminar. It is used to work out similar solutions to the local equations of a turbulent boundary layer with small cross-flow. In a compressible fluid with arbitrary pressure gradients, a digital routine enables sets of transverse and longitudinal boundary-layer profiles and the wall skin-friction components to be determined as a function of tow parameters expressing the influence of pressure gradients. A comparison with experimental results shows a measure of agreement. The model offers the requisite hypotheses on which to build an integral method of computing three-dimensional turbulent boundary layers.
Author

N72-20285# National Aerospace Lab., Amsterdam (Netherlands).
A CALCULATION METHOD FOR THREE DIMENSIONAL INCOMPRESSIBLE TURBULENT BOUNDARY LAYERS
P. Wesseling and J. P. F. Lindhout *In* AGARD Turbulent Shear Flows Jan. 1972 13 p refs (See N72-20273 11-12)
Avail: NTIS HC $6.00/MF $0.95

A system of partial differential equations which can be used as a mathematical model for three-dimensional incompressible turbulent boundary layers is discussed. Certain mathematical properties of these equations are elucidated. The equations have a finite domain of dependence, this fact simplifies the problem of calculating three-dimensional boundary layer flows. The equations are solved numerically by means of a simple linear explicit finite difference scheme. The choice of an efficient difference scheme is guided by two criteria for the stability of linear difference schemes with constant coefficients. The method is used to calculate several experimental flows.
Author

N72-20286*# Aeronautical Research Associates of Princeton, Inc., N.J.
A PROGRESS REPORT ON THE ATTEMPT TO CONSTRUCT AN INVARIANT MODEL OF TURBULENT SHEAR FLOWS
Coleman duP. Donaldson *In* AGARD Turbulent Shear Flows Jan. 1972 24 p refs (See N72-20273 11-12)
(Contract NASw-1868)
(NASA-CR-125904) Avail: NTIS CSCL 20D

The results of comparing computations using a tentative model of turbulent shear flows with experimental data are presented for the axially symmetric free jet, the two-dimensional free shear layer, and the flat plate boundary layer. The need for more carefully designed and documented free turbulent flow measurements is discussed in relation to the problem of selecting more refined models. Some observations are also made concerning the application of double correlation closure schemes to the computation of turbulent flows other than classical incompressible shear layers. In particular, the possibility of other methods of calculating the behavior of chemically reacting turbulent flows is examined.
Author

N72-20287# Delaware Univ., Newark.
A RE-EVALUATION OF ZERO PRESSURE GRADIENT COMPRESSIBLE TURBULENT BOUNDARY LAYER MEASUREMENTS
James E. Danberg *In* AGARD Turbulent Shear Flows Jan. 1972 11 p refs (See N72-20273 11-12)
Avail: NTIS HC $6.00/MF $0.95

Compressible turbulent boundary layer velocity and temperature profiles with zero pressure gradient were collected and prepared for computer analysis. An assumed equation for these profiles was chosen allowing four constants to be adjusted by a nonlinear least squares technique. The four constants are a velocity scale, boundary layer thickness, the constant of the semi-log region and the wake constant. This equation is analogous to Cole's incompressible law of the wall and wake but uses a generalized velocity to account for compressibility. Measurements from 45 adiabatic wall tests were analyzed covering a Mach number range from 2 to 6. Of these profiles, 29 included skin friction balance data which allowed direct evaluation of the universal constant of turbulence (mean value of κ = .43) through comparison between the shear velocity and the profile velocity scale. The constants of the semi-log and the wake region were found to be independent of Reynolds and Mach numbers. A similar analysis was carried out for the limited number of total temperature profiles.
Author

N72-20288# Royal Aircraft Establishment, Bedford (England).
SOME BOUNDARY LAYER MEASUREMENTS ON A FLAT PLATE AT MACH NUMBERS FROM 2.5 TO 4.5
D. G. Mabey, H. U. Meier (Deutsche Forschungs-und Versuchsanstalt fuer Luft und Raumfahrt, Goettingen), and W. G. Sawyer *In* AGARD Turbulent Shear Flow Jan. 1972 11p refs (See N72-20273 11-12)
Avail: NTIS HC $6.00/MF $0.95

An experimental investigation of the turbulent boundary layer on a large, thermally insulated flat plate is reported, in which Mach number and total temperature profiles and shear stress at the wall were measured. The measured velocity profiles are found to be in good agreement with theoretical treatments. Similarly, the measured skin-friction coefficients are predicted flat-plate skin-friction laws. The form of the total temperature profile close to the wall suggests an increase in turbulent Prandtl number as the wall is approached. At all conditions, the wall temperature was found to be higher than would be expected in adiabatic flow conditions, while there was a substantial deficit of enthalpy flux within the boundary layer.
Author

N72-20289# National Aeronautical Establishment, Ottawa (Ontario).
COMPARISONS BETWEEN SOME HIGH REYNOLDS NUMBER TURBULENT BOUNDARY LAYER EXPERIMENTS AT MACH 4, AND VARIOUS RECENT CALCULATION PROCEDURES
D. J. Peake, G. Brakmann (McGill Univ.), and J. M. Romeskie (McGill Univ.) *In* AGARD Turbulent Shear Flows Jan. 1972 70 p refs (See N72-20273 11-12)
Avail: NTIS HC $6.00/MF $0.95

The objective was to assess the influence of streamwise pressure gradients upon two dimensional compressible turbulent boundary layers at high Reynolds numbers, in the absence of end-wall effects and longitudinal curvature effects. Boundary layers recovering to equilibrium conditions were emphasized. Measurements were made at a Mach 4 of pressure distribution, local skin friction, and boundary-layer profiles along the internal surface of a parallel, circular cross-section duct. The Reynolds number based on the duct length of 33 inches was almost 50 million. Results from three experiments are presented, namely a near zero pressure gradient flow, an adverse pressure gradient

case, and a flow relaxing downstream of a step induced separation. The boundary layer predictions of all the methods were in reasonable agreement with experiment. The outstanding exception was the discrepancy observed between the calculated and experimental skin friction results in the adverse pressure gradient flow, which was attributed tentatively to the static pressure gradient across the boundary layer in the region of the streamwise pressure increase Author

N72-20290# Johns Hopkins Univ., Baltimore, Md.
THE STRUCTURE OF TURBULENCE IN SHEAR FLOWS
Leslie S. G. Kovasznay *In* AGARD Turbulent Shear Flows Jan 1972 14 p refs (See N72-20273 11-12)
(Contract F44620-69-C-0023)
Avail NTIS HC $6.00/MF $0.95

Results obtained by flow visualization techniques have given inspiration for devising plausible models rather than have provided numerical data to be compared with experiments. Hot-wire anemometer records, especially by employing appropriate signal processing techniques have given quantitative data that can be used for direct comparison with theoretical predictions. Theoretical possibilities are reviewed, and arguments are presented for favoring a model consisting of random sprinkled, but deterministic flow structures against models based on travelling waves. A suggestion for a possible form of mean flow predictions schemes is outlined Author

N72-20291# ARO, Inc., Arnold Air Force Station, Tenn.
FREE TURBULENT MIXING: A CRITICAL EVALUATION OF THEORY AND EXPERIMENT
Philip T. Harsha *In* AGARD Turbulent Shear Flows Jan 1972 11 p refs (See N72-20273 11-12)
(Contract F40600-71-C-0002; AF Proj. 9711)
Avail NTIS HC $6.00/MF $0.95

A group of models for the turbulent shear stress, ranging from the classical Prandtl mixing length theory to the kinetic energy models, are systematically confronted with a broad range of experimental data. Two sets are developed (1) those models suitable for engineering use, and (2) the models which show promise of becoming applicable with further development to turbulent free mixing. Author

N72-20292# California Univ., La Jolla. Dept. of Aerospace and Mechanical Engineering Sciences
JET TURBULENCE: DISSIPATION RATE MEASUREMENTS AND CORRELATIONS
Carl A. Friehe, C. W. VanAtta, and Carl H. Gibson *In* AGARD Turbulent Shear Flows Jan 1972 7 p refs (See N72-20273 11-12)
(Contract F44620-68-C-0010; Proj. THEMIS)
Avail NTIS HC $6.00/MF $0.95

A correlation of the mean rate of dissipation on the center-line in terms of the orifice Reynolds number and axial position is established. Measurements of the velocity and velocity derivative are described for a jet of orifice Reynolds number of 1.2 x 10 to the 5th power. The spectrum of the square of the velocity derivative was found to be similar to those obtained for atmospheric boundary layer flows at very large Reynolds numbers when normalized with Kolmogoroff length and time scales. Spectra of higher order moments of the velocity derivative are also presented and compared to Novikov's predictions of the power law subranges Author

N72-20293# Vereinigte Flugtechnische Werke G.m.b.H., Bremen (West Germany)
VELOCITY AND DENSITY MEASUREMENTS IN A FREE JET
O. H. Wehrmann *In* AGARD Turbulent Shear Flows Jan 1972 9 p refs (See N72-20273 11-12)
Avail NTIS HC $6.00/MF $0.95

The fluctuating properties in a turbulent flow are due to convection, diffusion, production, dissipation, and pressure transport. To perform an energy balance, not only velocity terms have to be measured, but also the pressure or density components of the pressure transport term. Velocity fluctuations can be measured by the hot-wire technique; in contrast to this, the local measurement of the density fluctuations presents a certain problem, especially if the disturbance of the flow field by a density measuring would have to be kept as small as possible. To obtain a local measurement, a focussed laser beam Mach-Zehnder interferometer was used. The flow measurements were made for the flow field behind a 2.5 cm nozzle at a flow velocity of 43 m/sec. The flow in the center of the nozzle at the exit plane was laminar or made turbulent by the insertion of a screen. Author

N72-20294# Technical Univ. of Denmark, Lyngby. Dept. of Fluid Mechanics
AN EXPERIMENTAL INVESTIGATION OF CURVED TWO DIMENSIONAL TURBULENT JETS
C. Schwartzbach *In* AGARD Turbulent Shear Flows Jan 1972 12 p refs (See N72-20273 11-12)
Avail NTIS HC $6.00/MF $0.95

Hot-wire measurements of mean velocity and normal turbulent stress in the direction of flow are presented for the flow field generated by a plane jet reattaching to a flat plate adjacent to the jet nozzle. Measurements were made in longitudinal and lateral traverses of the curved jet flow and in the two wall jet flows. Measurements were made in two series for thirteen different positions of the adjacent plate thereby providing data for differing values of jet curvature and jet pathlengths. Integral methods were used on the experimental data to evaluate the effect of jet curvature on the entrainment along the external and internal boundaries of the curved jet Author

N72-20295# California Inst. of Tech., Pasadena
THE EFFECT OF DENSITY DIFFERENCE ON THE TURBULENT MIXING LAYER
Garry V. Brown and Anatol Roshko *In* AGARD Turbulent Shear Flows Jan 1972 12 p refs Supported by ONR (See N72-20273 11-12)
Avail NTIS HC $6.00/MF $0.95

An experimental study was made of the turbulent mixing layer between two streams of different gases, especially nitrogen and helium. This was made in a flow apparatus, designed to produce good quality flow at pressures up to 10 atmospheres with run times as low as 1 or 2 seconds. High speed measurement techniques, including a density probe, were used. Shadowgraphs of the turbulent mixing layer reveal a large-scale structure similar to that in the late stages of instability development in a laminar free shear layer. The similarity properties of the mixing layers are established from profiles of mean velocity and density, and from these the basic flow parameters are computed, spreading rate, dissipation rate, shear stress distribution. It is found that a large density ratio (e.g., 7:1) in the two streams does not have a great effect on the spreading rate; this contrasts with the large effect of Mach number on the turbulent spreading of a free shear layer at the edge of a supersonic flow. A brief analysis compares the effects of density nonuniformities in low speed flow and those due to compressibility at high Mach number Author

N72-20296# Defence Research Establishment Valcartier (Quebec)
FLUID DYNAMIC PROPERTIES OF TURBULENT WAKES OF HYPERSONIC SPHERES
J. G. G. Dionne, D. Heckman, C. Lahaye, L. Sevigny, and L. Tardif *In* AGARD Turbulent Shear Flows Jan 1972 13 p refs (See N72-20273 11-12)
(ARPA Order 133)
Avail NTIS HC $6.00/MF $0.95

Representative data, concerning the mean behavior of velocity and density in the wakes of hypersonic spheres launched at Mach 13 and a pressure times sphere density of 20 torr-inches, are given. The variation with axial distance of the

velocity, density, and temperature defects and of the velocity and density wake radii are given and are compared with other similar data and with schlieren data obtained under the same conditions. Data on turbulent characteristics such as velocity fluctuations, ionization scale lengths and wake intermittency are also given. Finally, the total momentum in the wake is estimated from the measured velocity and mass density distributions.
Author

N72-20297# Avco Everett Research Lab., Everett, Mass.
MEASUREMENTS OF THE INSTANTANEOUS SPATIAL DISTRIBUTION OF A PASSIVE SCALAR IN AN AXISYMMETRIC TURBULENT WAKE
Arthur M. Schneiderman *In* AGARD Turbulent Shear Flows Jan. 1972 12 p refs (See N72-20273 11-12)
(Contract F04701-70-C-0128)
Avail: NTIS HC $6.00/MF $0.95

The spatial mixing field in the turbulent wake of a longitudinally aligned truncated cylinder at a Mach number of 2.5 and a Reynolds number of 1 million (based on diameter) is observed experimentally using the laser planogram technique. The instantaneous spatial distribution of a tracer material introduced at the model is characterized statistically by estimates of the probability density function, energy spectrum and autocovariance coefficient of the measured fluctuations. Wake axis measurements over the region from 138 to 182 body diameters yield turbulent concentration fluctuations of 25% and skewness and kurtosis of +0.18 and +0.16, respectively. A centerline intermittency of approximately 82% is observed. A classical turbulence spectrum with a well defined break from a flat to a k to the minus 5/3 power inertial subrange is found. The autocovariance coefficient yields a macroscale which is approximately half the transverse scale length. The wake boundary is observed to be substantially more contorted than had previously been suspected.
Author

N72-20298# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)
RECENT ATTEMPTS TO DEVELOP A GENERALLY APPLICABLE CALCULATION METHOD FOR TURBULENT SHEAR FLOW LAYERS
J. C. Rotta *In* AGARD Turbulent Shear Flows Jan. 1972 11 p refs (See N72-20273 11-12)
Avail: NTIS HC $6.00/MF $0.95

Calculation methods are discussed, which are based on the differential equations for the Reynolds stresses. The considerations restrict themselves to two-dimensional flow fields for which the usual boundary layer approximations apply. In many of the proposed methods of this kind the equation for the kinetic fluctuation energy plays a central role. The transport equation for the Reynolds shear stress includes as special cases Prandtl's eddy viscosity relation and Bradshaw's assumption of a constant ratio of shear stress to kinetic fluctuation energy. A differential equation for the integral length scale is derived from Navier-Stokes equations, and the closure assumptions are given. It turns out that the simplified version of the length scale equation used by some authors is not capable of reproducing the characteristics of different kinds of flows. The main reason for this shortcoming is found in an oversimplification of the turbulence production term of the length scale equation. The arguments are illustrated by calculated results.
Author

N72-20299# Naval Ordnance Lab., White Oak, Md.
AN EXPERIMENTAL STUDY OF THE COMPRESSIBLE TURBULENT BOUNDARY LAYER WITH AN ADVERSE PRESSURE GRADIENT
Robert L. P. Voisinet, Roland E. Lee, and William J. Yanta *In* AGARD Turbulent Shear Flows Jan. 1972 10 p refs (See N72-20273 11-12)
Avail: NTIS HC $6.00/MF $0.95

The results of a detailed experimental investigation of the compressible turbulent boundary layer in an adverse pressure gradient regime are presented. The studies were conducted on a flat nozzle wall for Mach numbers between 4.1 and 4.9, at momentum thickness Reynolds numbers from 5600 to 69,000 and at wall-to-adiabatic-wall temperature ratios of 1.0 and 0.8. Complete and often redundant profile measurements were taken with Pitot and static-pressure probes and conical equilibrium and fine-wire temperature probes. The wall shear and surface heat transfer were measured directly with a skin-friction balance and a heat-transfer gage. The effect of the adverse-pressure-gradient flow on the boundary-layer flow structure, friction drag, and heat transfer, as compared with zero- and favorable-pressure gradient flow, is discussed. A test showing the effect of nozzle throat cooling on the downstream boundary layer is also reported. This throat cooling caused significant changes in the downstream temperature profiles and recovery factor with no effect on the local wall shear.
Author

N72-20300# Ballistic Research Labs., Aberdeen Proving Ground, Md.
THE SUPERSONIC TURBULENT BOUNDARY LAYER IN AN ADVERSE PRESSURE GRADIENT: EXPERIMENT AND DATA ANALYSIS
Walter B. Sturek and James E. Danberg (Delaware Univ., Newark) *In* AGARD Turbulent Shear Flows Jan. 1972 13 p refs (See N72-20273 11-12)
Avail: NTIS HC $6.00/MF $0.95

Experimental measurements of the profile characteristics of the supersonic turbulent boundary layer in a region of moderate adverse pressure gradient along a two-dimensional isentropic ramp model are reported. The data are for a closely adiabatic wall at a tunnel nozzle setting of M = 3.54. Detailed surveys of impact pressure, static pressure and total temperature were made, and wall shear stress was measured using the Preston tube technique. In addition to the mean profile data, fluctuation data were obtained using constant temperature hot-wire anemometry in the zero pressure gradient flow upstream of the ramp model and in the adverse pressure gradient flow along the ramp model. Turbulent boundary layer equations applicable to compressible flow over a surface with longitudinal curvature are analyzed. Corrections for longitudinal curvature to the equation for conservation of streamwise momentum are shown to be small and of the same order of magnitude as the contribution of the wall shear stress. The data are shown to correlate in law of the wall and velocity defect dimensionless coordinates using an integral compressibility transformation that follows directly from Prandtl's mixing length approximation of the Reynolds' stress. Eddy viscosity and mixing length distributions for the zero pressure gradient boundary layer were determined directly from the experimental data and agree qualitatively with previously published findings. The measured value of skin friction coefficient is 20 percent less for the flow over the ramp model than for the zero pressure gradient flow upstream.
Author

N72-20301# Imperial Coll. of Science and Technology, London (England). Aeronautics Dept.
TURBULENT BOUNDARY LAYERS AT SUPERSONIC AND HYPERSONIC SPEEDS
G. T. Coleman, G. M. Elfstrom, and J. L. Stollery *In* AGARD Turbulent Shear Flows Jan. 1972 9 p refs (See N72-20273 11-12)
Avail: NTIS HC $6.00/MF $0.95

The growth of a compressible turbulent boundary layer over flat plate and compression corner models was studied at a Mach number of 9. Local Mach numbers between 3 and 9 were achieved on a flat plate by varying the incidence from 0 to 26.5 deg. The local unit Reynolds numbers used were between 150,000 and 700,000. The measurements, which include pressure and heat transfer rate distributions and pitot pressure profiles across the boundary layer, extend the range of existing data and are used to test some current prediction methods and to emphasize some features of lower Mach number flows. Heat transfer rate distributions at Mach numbers of 3, 5 and 9 show an increasing discrepancy between experiment and theory as the Mach number rises, the data being higher than the predicted

value but approaching it asymptotically with increasing momentum thickness Reynolds number (Re theta) The boundary layer profiles taken at Mach 9 grew fuller as Re theta decreased, both of these results are associated with the slow development of the wake component of the turbulent boundary layer profile at high Mach numbers Author

N72-20302# Queen Mary Coll, London (England)

AN EXPERIMENTAL INVESTIGATION OF THE TURBULENT BOUNDARY LAYER ALONG A STREAMWISE CORNER

O O Mojola and A D Young *In* AGARD Turbulent Shear Flows Jan 9 1972 9 p refs (See N72-20273 11-12)

Avail NTIS HC $6.00/MF $0.95

A selection of results are presented of an extensive experimental investigation of steady incompressible turbulent boundary layer along a smooth 90 degree streamwise corner, formed by a pair of identical intersecting flat plates, with the freestream velocity directed parallel to the cornerline Detailed explorations of the flow with and without external pressure gradients, included the determination of static pressure fields the mean velocities wall shear stresses, and the components of the Reynolds (turbulent) stress tensor A secondary flow towards the corner along the plane of symmetry and outwards from it close to the walls forming the corner is a vital and characteristic feature and is clearly reflected in the mean and turbulence flow measurements In particular, it modifies the relations between the shear stress components and turbulence energy and mean velocity distribution so as to make any simple extension of current methods of turbulent boundary layer prediction unlikely to be applicable in such a flow Author

N72-20303# Office National d Etudes et de Recherches Aerospatiales, Paris (France)

INJECTION OF A TURBULENT BOUNDARY LAYER WALL WITH A STRANGE GAS [COUCHE LIMITE TURBULENTE AVEC INJECTION A LA PAROI D'UN MEME GAZ OU D'UN GAZ ETRANGER]

T Lili and R Michel *In* AGARD Turbulent Shear Flows Jan 1972 10 p refs In FRENCH, ENGLISH summary (See N72-20273 11-12)

Avail NTIS HC $6.00/MF $0.95

An improved mixing-length model is applied to the theoretical determination of a turbulent boundary layer, with transfer of fluid at the wall, and the results are compared point by point with available experimental evidence In the incompressible field there are first provided some solutions to the local equations of an equilibrium boundary layer to define the requisite set of velocity profiles and skin friction law for an air injection with pressure gradient Next, the velocity and concentration profiles are worked out for foreign gas injected Lastly the solution is extended to cover the general case of a compressible fluid leading to a systematic set of results for the effect of injection upon skin friction and heat transfer shown as a function of Mach number and wall temperature Author

N72-20304# California Inst of Tech Pasadena

A SURVEY OF DATA FOR TURBULENT BOUNDARY LAYERS WITH MASS TRANSFER

Donald Coles *In* AGARD Turbulent Shear Flows Jan 1972 15 p refs (See N72-20273 11-12)

Avail NTIS HC $6.00 MF $0.95

A critical survey is made of available experimental data on turbulent boundary layers with mass transfer in the absence of complicating factors such as compressibility and pressure gradient Two approaches to the data show particular promise The first is the mixing length approach which leads (as is well known) to a set of modified coordinates such that the classical similarity laws outside the sublayer seem to remain valid down to the last detail at least for moderate values of suction or blowing The second approach is more original it is an attempt to generalize the kind of analysis often used to develop similarity laws for free shear flows such as wakes or jets while preserving intact an argument which extends these ideas to the case of boundary layer

glow The essential step is the definition of a characteristic velocity (qua friction velocity) in terms of a characteristic stress (qua wall stress) which occurs somewhere in the layer A strong precedent for such a step can be found in the usual treatment of surface roughness So far, the best choice for the characteristic stress seems to be some kind of average value for the sublayer Author

N72-20305# Stanford Univ, Calif Dept of Mechanical Engineering

THE SUPPRESSION OF SHEAR LAYER TURBULENCE IN ROTATING SYSTEMS

James P Johnston *In* AGARD Turbulent Shear Flows Jan 1972 9 p refs (See N72-20273 11-12)

(Grants NSF GK-2533, NSF GK-16450)

Avail NTIS HC $6.00/MF $0.95

Stabilization of turbulent boundary layer type flows by the action of coriolis forces engendered by system rotating is studied Experiments on fully-developed, two-dimensional flow in a long, straight channel that was rotated about an axis perpendicular to the plane of mean shear are reviewed to demonstrate the principle effects of stabilization In particular, the delay of transition to turbulence on the stabilized side of the channel to high Reynolds number as the rotating number is increased is demonstrated A simple method, that utilizes the eddy Reynolds number criterion of Bradshaw, is employed to show that rotating induced suppression of transition may be predicted for the channel flow case The applicability of the predictive method to boundary layer type flows is indicated Author

N72-20306# Lyon Univ (France)

DEVELOPMENT OF A TURBULENT BOUNDARY LAYER ON A FLAT PLATE IN AN EXTERNAL TURBULENT FLOW

G Charnay, G Comte-bellot and J Mathieu *In* AGARD Turbulent Shear Flows Jan 1972 9 p refs (See N72-20273 11-12)

Avail NTIS HC $6.00 MF $0.95

The development of a turbulent boundary layer on a flat plate was experimentally investigated in the presence of an external turbulent flow generated by grids With reference to a turbulent boundary layer evolving in an undisturbed flow the following results were observed when the external turbulence level is increasing (1) the boundary layer grows more rapidly (2) the wall shear stress is higher, (3) in the outer region of the layer the mean velocity profile becomes flatter and the law of the wake is modified In the same region the turbulent levels are increased, and the turbulent shear stress and the turbulent kinetic energy production become large Various integral length scales of the external turbulent flow were also used A discernable effect was observed on the integral scales of the boundary layer only A rearrangement of the external isotropic turbulence, due to the straining process of the mean existing velocity gradient in the boundary layer is tentatively proposed Author

N72-20307# Imperial Coll of Science and Technology London (England) Dept of Aeronautics

SOME MEASUREMENTS OF THE DISTORTION OF TURBULENCE APPROACHING A TWO DIMENSIONAL BODY

P W Bearman *In* AGARD Turbulent Shear Flows Jan 1972 11 p refs (See N72-20273 11-12)

Avail NTIS HC $6.00 MF $0.95

A description is given of the distortion of grid generated turbulence as it approaches the stagnation region of a two dimensional body When L sub x D is much greater than 1 (where L sub x is the scale of turbulence and D is a typical body dimension) along the mean stagnation streamline the longitudinal component of the velocity fluctuations attenuates like the mean flow Whereas if L sub x D is much less than 1 the turbulence is distorted by the mean flow field and the longitudinal component of the velocity fluctuations will be amplified due to the vortex

stretching When L sub x/D = O(1) a combination of these effects is found with attenuation of energy at low wave numbers and amplification at high wave numbers Measurements of the pressure fluctuations at the stagnation point show that at low wave numbers the level of the pressure fluctuations can be predicted by assuming the turbulence to be irrotational   Author

N72-27293# Advisory Group for Aerospace Research and Development. Paris (France)
NUMERICAL METHODS IN FLUID DYNAMICS
J J Smolderen, ed May 1972 328 p refs Partly in ENGLISH and partly in FRENCH
(AGARD-LS-48) Avail NTIS HC $18 50

Numerical analysis and approximation are considered for gas and fluid flow problems in fluid dynamics Navier-Stokes and other equations of motion are discussed, as well as various finite element methods For individual titles, see N72-27294 through N72-27308

N72-27294 Von Karman Inst for Fluid Dynamics, Rhode Saint Genese (Belgium)
INTRODUCTORY REMARKS
J J Smolderen *In* AGARD Numerical Methods in Fluid Dyn May 1972 8 p (For availability see N72-27293 18-12)

The basic mathematical problems of fluid mechanics are reviewed and the various numerical techniques available to solve partial differential equations are presented Their advantages and limitations are briefly discussed   Author

N72-27295 Paris Univ (France)
ON THE NUMERICAL APPROXIMATION OF SOME EQUATIONS ARISING IN HYDRODYNAMICS
J L Lions *In* AGARD Numerical Methods in Fluid Dyn May 1972 13 p refs (For availability see N72-27293 18-12)

Examples are developed of equations arising in hydrodynamics for the following (1) approximation of systems which are not of the Cauchy Kowaleska type by systems of that type (2) the possibilities of splitting the systems of the Cauchy-Kowaleska type, and (3) the splitting of coupled systems   Author

N72-27296 Paris Univ, Orsay (France)
APPROXIMATION OF NAVIER STOKES EQUATIONS
R Teman *In* AGARD Numerical Methods in Fluid Dyn May 1972 6 p refs (For availability see N72-27293 18-12)

Methods of approximation of the full Navier-Stokes equations are discussed The problem considered is the unsteady flow (and sometimes the steady flow) of an incompressible viscous fluid in a bounded domain The problem possesses a unique solution in the case of a two-dimensional flow In the case of a three dimensional flow the problem possesses at least one solution but uniqueness is known only when the vectors f,g and u sub 0 are sufficiently small for Re fixed (laminar flow) Three kinds of approximation methods are described (1) the penalty method (2) perturbation and fractional step method and (3) the fractional step method   Author

N72-27297 Laval Univ (Quebec)
THE APPROXIMATION OF NAVIER STOKES EQUATIONS FOR VISCOUS INCOMPRESSIBLE FLUIDS [SUR L'APPROXIMATION DES EQUATIONS DE NAVIER STOKES DES FLUIDES VISQUEUX INCOMPRESSIBLES]
M Fortin and R Temam (Paris Univ Orsay) *In* AGARD Numerical Methods in Fluid Dyn May 1972 7 p refs In FRENCH (For availability see N72-27293 18-12)

The problem considered is that of nonstationary flow of a viscous incompressible fluid in a bounded domain Omega If the vector u is designated as the velocity vector p as pressure and f as the given forces the equations of motion are written in the classical manner in conservational form Initial and limiting condition are also given The method discussed here is an interpretation of the fractional step method   Transl by K P D

N72-27298 Laval Univ (Quebec)
NUMERICAL SOLUTION OF STEADY STATE NAVIER-STOKES EQUATIONS
M Fortin *In* AGARD Numerical Methods in Fluid Dyn May 1972 8 p refs (For availability see N72-27293 18-12)

The Navier-Stokes equations of a viscous incompressible fluid in a bounded domain are considered Only two-dimensional cases are treated but some results and all numerical schemes may be extended to the three-dimensional flow Existence and uniqueness of solutions are discussed The results especially those concerning uniqueness are used to explain the difficulties encountered in the convergence proofs of the methods   Author

N72-27299 International Business Machines Corp, San Jose, Calif
NUMERICAL SOLUTION OF THE NAVIER-STOKES EQUATIONS AT HIGH REYNOLDS NUMBERS AND THE PROBLEM OF DISCRETIZATION OF CONVECTIVE DERIVATIVES
Jacob E Fromm *In* AGARD Numerical Methods in Fluid Dyn May 1972 47 p ref (For availability see N72-27293 18-12)

The essentials of numerical computation of time-dependent nonlinear fluid flows are discussed The case under consideration is that of incompressible flow with viscosity described in terms of a vorticity and stream function   Author

N72-27300 Polytechnic Inst of Brooklyn, Farmingdale, N Y Graduate Center
NUMERICAL ANALYSIS OF VISCOUS ONE DIMENSIONAL FLOWS
G Moretti and M D Salas *In* AGARD Numerical Methods in Fluid Dyn May 1972 20 p refs Presented at Meeting on Appl of Numerical Methods in M d Gasdyn, Novosibirsk, USSR 17-24 Aug 1969 (For availability see N72-27293 18-12)

The flow of a viscous, heat-conducting gas produced by an accelerating piston is analyzed numerically The formation of a shock in a viscous flow is studied A discussion of accuracy and practicality of a numerical analysis of the problem is given It is concluded that the assumption of a shock as a sharp discontinuity is the only practical way to handle flows whose Reynolds number per unit length is higher than 100   Author

N72-27301 Polytechnic Inst of Brooklyn, Farmingdale, N Y Graduate Center
A CRITICAL ANALYSIS OF NUMERICAL TECHNIQUES. THE PISTON DRIVEN INVISCID FLOW
G Moretti *In* AGARD Numerical Methods in Fluid Dyn May 1972 31 p refs (For availability see N72-27293 18-12)
(Contract Nonr-839(38), ARPA Order 529)

An analysis of procedures for the computation of one-dimensional shocked flow was made in order to show the inconveniences of computing finite differences across a discontinuity and to prove that the use of the equations of motion in conservation form does not make the results more accurate A technique was developed to treat one-dimensional inviscid problems, and it is applied to the problem of an accelerating piston Ways to predict the formation of a shock and to follow its evolution are given   Author

N72-27302 Polytechnic Inst of Brooklyn, Farmingdale N Y Graduate Center
TRANSIENT AND ASYMPTOTICALLY STEADY FLOW OF AN INVISCID, COMPRESSIBLE GAS PAST A CIRCULAR CYLINDER
G Moretti *In* AGARD Numerical Methods in Fluid Dyn May 1972 19 p refs (For availability see N72-27293 18-12)
(Contract DAHC04 69 C 0077)

A numerical analysis is made of the inviscid flow produced by a cylinder which accelerates from a state of rest to a constant subsonic speed in a gas at rest All features of the

numerical solution are explained on physical grounds Ways are suggested to compute steady subsonic flows around obstacles with a maximum accuracy and a minimum computational time
Author

N72-27303 Polytechnic Inst of Brooklyn Farmingdale N Y Graduate Center
THE BLUNT BODY PROBLEM FOR A VISCOUS RAREFIED GAS FLOW
G Moretti and M D Salas *In* AGARD Numerical Methods in Fluid Dyn May 1972 15 p refs (For availability see N72-27293 18-12)
(Contract Nonr-839(34))

A time-dependent technique developed for inviscid blunt body flows was extended to analyze the viscous layer regime (a rarefied gas situation where viscosity affects most of the shock layer but not the shock wave itself) Navier-Stokes equations were used To maintain accuracy, the (nonlinear) mesh spacing was adjusted automatically to the nature of the velocity distribution between shock and body In this way, a wide range of Reynolds numbers can be scanned The technique could also be used at high Reynolds numbers, when the shock layer is practically inviscid and viscous effects are confined to a boundary layer Discussion of numerical experiments is given
Author

N72-27304 Polytechnic Inst of Brooklyn Farmingdale N Y Graduate Center
THE CHOICE OF A TIME DEPENDENT TECHNIQUE IN GAS DYNAMICS
G Moretti *In* AGARD Numerical Methods in Fluid Dyn May 1972 30 p refs (For availability see N72-27293 18-12)
(Contract Nonr-839(34))

A definition of the word technique, as related to numerical computations of time-dependent problems in gas dynamics, is given Requirements of accuracy, economy, and flexibility are considered A technique which attempts to satisfy them is presented Emphasis is put on the consistency of the numerical procedure with the physical problem The concepts of consistency convergence and truncation error are reexamined Certain breakdowns in accuracy occurring in regions of continuous flow are explained The physical role played by discontinuities and its numerical counterpart are discussed
Author

N72-27305 Cambridge Univ (England) Engineering Dept
APPLICATION OF FINITE ELEMENT METHODS IN FLUID DYNAMICS
D H Norrie and G deVries (Calgary Univ Alberta) *In* AGARD Numerical Methods in Fluid Dyn May 1972 43 p refs (For availability see N72-27293 18-12)

The classification of finite element methods is presented Generalized Lagrangian and Hermitian shape functions are discussed in relation to the finite element approximation Variational finite element methods are considered for equilibrium eigenvalue and propagation problems Direct finite element methods are also discussed Steady and unsteady potential flow porous media flows viscous flow general fluid flows, and other fluid applications are reviewed The cell finite element method is also considered
K P D

N72-27306 Boeing Co Seattle Wash
COMPUTATIONAL METHODS FOR INVISCID TRANSONIC FLOWS WITH IMBEDDED SHOCK WAVES
Earll M Murman *In* AGARD Numerical Methods in Fluid Dyn May 1972 36 p refs (For availability see N72-27293 18-12)

Time dependent techniques relaxation methods and approximate solutions are considered with emphasis placed on the latest developments Computing times accuracy and proper treatment of shock waves are stressed
Author

N72-27307 Freiburg Univ (West Germany)
NUMERICAL TREATMENT OF TIME DEPENDENT THREE DIMENSIONAL FLOWS
K G Roesner *In* AGARD Numerical Methods in Fluid Dyn May 1972 31 p refs (For availability see N72-27293 18-12)

The numerical treatment of three-dimensional time-dependent flows of an ideal gas with constant ratio of specific heats was investigated It is assumed that inside the flow field, no discontinuities occur As boundaries, fixed or moving rigid body surfaces and shock waves were allowed This type of gas flow is described by the Euler equations with appropriate initial and boundary conditions The mathematical tools applied to this gas dynamical problem are (1) the method of characteristics, and (2) the method of fractional steps The application of these methods is discussed for some definite problems, one being the time-dependent inlet flow through a nozzle with a three-dimensional shape of its contour the other the time-dependent supersonic flow around blunt bodies with various shapes of their surfaces A comparison was made between the two methods with respect to their effectiveness
Author

N72-27308 Societe Grenobloise d Etude et d Applications Hydrauliques (France)
PETULA (PROGRAM FOR TURBULENT OR LAMINAR FLOWS) AN EXAMPLE OF A COMPLEX MATHEMATICAL MODEL IN FLUID MECHANICS [PETULA (PROGRAMME D'ECOULEMENTS TURBULENTS OU LAMINAIRES) UN EXEMPLE DE MODELE MATHEMATIQUE COMPLEXE EN MECHANIQUE DES FLUIDES]
M F Gauthier *In* AGARD Numerical Methods in Fluid Dyn May 1972 13 p refs In FRENCH (For availability see N72-27293 18-12)

The model definition, structure and empirical parameter identification are presented Limiting conditions and adaptive coordinate systems are considered Convergence is considered for the nonlinear model
Transl by K P D

N72-33267# Advisory Group for Aerospace Research and Development Paris (France)
EXPERIMENTS ON MANAGEMENT OF FREE-STREAM TURBULENCE
R I Loehrke (Ill Inst of Tech Chicago) and H M Nagib (Ill Inst of Tech Chicago) Sep 1972 113 p refs
(AGARD-R-598) Avail NTIS HC $7.75 CSCL 20D

The effects of various passive devices (screens perforated plates porous foam, and honeycomb-like matrices formed with closely packed plastic drinking straws) on free stream turbulence and mean velocity profiles are studied in air with hot wire anemometry and in water using hydrogen bubbles visualization These turbulence manipulators are viewed as operators which suppress the level of the incoming turbulence and generate primarily through documented instabilities new turbulence with scales characteristic of the device and its shear layers For honeycombs the suppression of the incoming turbulence appears to be mostly due to the inhibition of lateral components of the fluctuating velocity For most devices it is conjectured that part of the energy in the undesirable larger scales of motion drains away through the action of the Reynolds stresses of the smaller scale laminar and turbulent motions (including the instabilities) The performance of the manipulators is found to depend on the characteristics of the incoming turbulence including its frequency spectra level and spatial distribution and on the incoming mean flow profiles The efficacy of devices generating large scale turbulences in smoothing out gross inhomogeneities in the mean velocity profiles is illustrated
Author

N73-11262# Advisory Group for Aerospace Research and Development Paris (France)
TECHNICAL EVALUATION REPORT ON THE AGARD SPECIALISTS' MEETING ON TURBULENT SHEAR FLOWS
R Michel Jul 1972 22 p refs Conf held at London 13-15 Sep 1971
(AGARD-AR-46) Avail NTIS HC $3.25

The main techniques applied to present turbulent flow

studies theoretical and experimental are defined Attemps were also made to open avenues which may aid in such studies Data cover general problems phenomena and analytical techniques relating to the flows Turbulent boundary layers wakes, and jets are discussed E H W

N73-17248# Advisory Group for Aerospace Research and Development, Paris (France)
SUPERSONIC EJECTORS
J J Ginoux, ed (Von Karman Inst for Fluid Dyn) Nov 1972 184 p refs
(AGARDograph-163, AGARD-AG-163) Avail NTIS HC $11 25

A state of the art review on significant progress in the design of high performance supersonic ejectors is presented Specific summaries cover design methods for ejector systems with second throat diffusers, ejector flow models, ejector designs for various applications, and ducted mixing and burning in coaxial streams. For individual titles, see N73-17249 through N73-17253

N73-17249 Dornier-Werke G m b H , Friedrichshafen (West Germany)
ONE-DIMENSIONAL INVISCID ANALYSIS OF SUPERSONIC EJECTORS
H T Uebelhack *In* AGARD Supersonic Ejectors Nov 1972 p 1-16 refs (For availability see N73-17248 08-12)

The conservation equations are used to analyze the one dimensional flow patterns of supersonic ejectors Two regimes of ejector operation, the supersonic and mixed flow, were studied. E H W

N73-17250 Dornier-Werke G m b H., Friedrichshafen (West Germany)
ANALYSIS AND DESIGN METHOD FOR EJECTOR SYSTEMS WITH SECOND THROAT DIFFUSERS
H T Uebelhack *In* AGARD Supersonic Ejectors Nov 1972 p 17-30 refs (For availability see N73-17248 08-12)

A flow model which permits the determination of starting and operating characteristics of a second throat ejector system is defined Working equations are derived and design procedures described The limits of application were discussed and compared with experiments Author

N73-17251 Illinois Univ., Urbana Dept of Mechanical and Industrial Engineering
THE ANALYSIS OF SUPERSONIC EJECTOR SYSTEMS
A L Addy *In* AGARD Supersonic Ejectors Nov 1972 p 31-101 refs (For availability see N73-17248 08-12)

An analysis of the ejector flow model and its implementation is presented Overall ejector performance characteristics were delineated on the bases of predominant flow mechanisms which occur within the various operating regimes Data on operating characteristics, qualitative aspects of the ejector flow model, and various problem areas or projected problem areas are examined Author

N73-17252 ARO, Inc , Arnold Air Force Station Tenn
EJECTOR DESIGN FOR A VARIETY OF APPLICATIONS
Delbert Taylor *In* AGARD Supersonic Ejectors Nov 1972 p 103-163 refs (For availability see N73-17248 08-12)
(Contract F40600-69-C-0001)

Methods and techniques developed to improve the performance and applications of various ejector designs are examined Data cover fixed value simple design and variable area / variable pressure ejectors E H W

N73-17253 ARO, Inc , Arnold Air Force Station, Tenn
ANALYSIS OF DUCTED MIXING AND BURNING OF COAXIAL STREAMS
C E Peters *In* AGARD Supersonic Ejectors Nov 1972 p 165-187 refs (For availability, see N73-17248 08-12)
(Contract F40600-69-C-0001)

An extensive theoretical and experimental investigation of ducted mixing was conducted The basic objective was to develop an adequate engineering theory to describe the ducted mixing process, including chemical reactions Emphasis was placed on relatively long mixing systems in which the mixing layer may extend over most or all of the duct cross section at the exit plane The duct pressure distribution will be strongly influenced by the thick mixing layers, and will be very different from the inviscid pressure distribution Three distinct flow regimes are shown in the mixing flow In the first regime, turbulent mixing occurs between the secondary flow and the core of inviscid primary flow In the second regime, the inviscid core has dissipated, but a region of inviscid secondary flow exists near the duct wall The third regime occurs after the mixing layer has spread to the wall, and the flow is entirely turbulent. Author

N73-26279# Advisory Group for Aerospace Research and Development, Paris (France) Fluid Dynamics Panel
FLUID MOTION PROBLEMS IN WIND TUNNEL DESIGN
Apr 1973 68 p refs
(AGARD-R-602, AGARD 602) Avail NTIS HC $5 50

A series of research papers is presented relating to the design and operation of low speed and transonic wind tunnels with particular emphasis on the associated fluid motion problems For individual titles, see N73-26280 through N73-26285

N73-26280 Deutsche Forschungs und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany) Inst fuer Angewandte Gasdynamik
THE INFLUENCE OF THE FREE-STREAM REYNOLDS NUMBER ON TRANSITION IN THE BOUNDARY LAYER ON AN INFINITE SWEPT WING
E H Hirschel *In* AGARD Fluid Motion Probl in Wind Tunnel Design Apr 1973 11 p refs (For availability see N73-26279 17-12)

The three-dimensional compressible laminar boundary layer on an infinite swept wing at different sweep angles is calculated and stability and transition criteria are applied to it for free-stream Reynolds numbers ranging from values possible nowadays in transonic wind tunnels to values typically for full scale flight The distribution of the inviscid flow is taken from experiments on airfoils and exhibits for subsonic free stream Mach numbers supersonic regions terminating in shock waves at about 20 percent chord length Results are given for four different wing sections The techniques employed and their shortcomings are discussed Author

N73-26281 Royal Aircraft Establishment, Farnborough (England)
SOME EXAMPLES OF THE APPLICATION OF METHODS FOR THE PREDICTION OF BOUNDARY-LAYER TRANSITION ON SHEARED WINGS
D A Treadgold and J A Beasley *In* AGARD Fluid Motion Probl in Wind Tunnel Design Apr 1973 1 p refs (For availability see N73 26279 17-12)

The laminar boundary layer was calculated for the leading-edge region of four selected airfoils for cases where the supercritical region is terminated by a shock wave at about 20% chord The possibility of the boundary layer becoming turbulent before the shock wave is then considered according to four different criteria leading edge contamination, re-laminarisation sweep instability and Tollmien-Schlichting instability Many simplifying assumptions have had to be made, since the purpose of the report is demonstrate how the problem might be treated, rather than to present difinitive results, and how the various mechanisms are seen in conjunction It is concluded that much more needs to be known before predictions can be made confidently with any degree of precision Author

N73-26282 Royal Aircraft Establishment Bedford (England)
THE NEED FOR HIGH REYNOLDS NUMBER TRANSONIC TUNNELS
C R Taylor *In* AGARD Fluid Motion Probl in Wind Tunnel Design Apr 1973 13 p refs (For availability see N73-26279 17-12)

The present generation of transonic tunnels cannot simulate full scale flow at critical points of the flight envelope for many

current aircraft designs and there is an urgent need for new tunnels which would permit model tests to be made at much higher Reynolds numbers. New tunnels are proposed that would allow good simulations of aircraft shape to be made for a wide range of model tests. this limits the maximum tunnel total pressure to about 8 bars. A Reynolds number range which covers about half the full-scale range is advocated. demanding a working section area of about 25m squared. The tunnels would have low levels of free-stream turbulence and be capable of operation under conditions giving little heat transfer to the model. Running times of at least 10 sec are required. Author

N73-26283 Royal Aircraft Establishment, Bedford (England).
ON THE INFLUENCE OF FREE-STREAM TURBULENCE ON A TURBULENT BOUNDARY LAYER, AS IT RELATES TO WIND TUNNEL TESTING AT SUBSONIC SPEEDS
J. E. Green *In* AGARD Fluid Motion Probl. in Wind Tunnel Design Apr. 1973 8 p refs (For availability see N73-26279 17-12)

Published experimental measurements are reviewed which show the turbulent boundary layer to be highly sensitive to turbulence in the free-stream. In zero pressure gradient a small increase in the streamwise rms velocity fluctuation is found to have the same effect on the shape of the velocity profile as a fractional increase in Reynolds number roughly sixty times as great. It is concluded that this effect needs to be taken into account in planning new wind tunnels for subsonic and transonic testing at high Reynolds number. Further experimental work is needed to clarify the importance of turbulence scale, the influence of pressure gradients and influence of radiated pressure (as opposed to convected vorticity) fluctuations. Author

N73-26284 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Berlin (West Germany). Inst. fuer Turbulenzforschung.
EFFECTS OF TURBULENCE AND NOISE ON WIND TUNNEL MEASUREMENTS AT TRANSONIC SPEEDS
Adalbert Timme *In* AGARD Fluid Motion Probl. in Wind Tunnel Design Apr. 1973 12 p refs (For availability see N73-26279 17-12)

Current knowledge is reviewed of the effects of flow unsteadiness on steady and dynamic measurements on models in wind tunnels at transonic speeds. It is found that in most cases the influence of the pressure or velocity fluctuations on flow patterns such as boundary layers with transition or separation bubble flow or shock interaction is quantitatively known from experiments only for particular parameter combinations. No universal information about the turbulence effect in different situations is found nor is there a general theory including all observed effects at conditions of interest. Only in the case of a turbulent boundary layer at zero pressure gradient a quantitative relation is known between the turbulence in the free stream and the boundary layer development. It is concluded therefore, that new experimental work using advanced measuring techniques and a secured theoretical background is urgently needed for planning new wind tunnels for transonic testing at high Reynolds numbers. Author

N73-26285 City Univ., London (England). Dept. of Aeronautics.
DESIGN OF VENTILATED WALLS WITH SPECIAL EMPHASIS ON THE ASPECT OF NOISE GENERATION
R. N. Cox and M. M. Freestone *In* AGARD Fluid Motion Probl. in Wind Tunnel Design Apr. 1973 7 p refs (For availability see N73-26279 17-12)

The parameters influencing the design of ventilated wind tunnel walls in current use are reviewed, and noise generation by such walls is analyzed. By drawing an analogy between results from flows past two-dimensional cavities and the discrete frequency tones generated by perforated walls, some suggestions are made about the mechanisms responsible for the tones. Finally some possible methods of reducing unwanted noise from tunnel walls are discussed. Author

N74-12042# Imperial Coll. of Science and Technology, London (England). Dept. of Aeronautics.
EFFECTS OF STREAMLINE CURVATURE ON TURBULENT FLOW
P. Bradshaw Paris AGARD Aug. 1973 30 p refs
(AGARD-AG-169; AGARDograph-169) Avail: NTIS HC $4.00

Streamline curvature in the plane of the mean shear produce surprisingly large changes in the turbulence structure of shear layers. These changes are usually an order of magnitude more important than normal pressure gradients and other explicit terms appearing in the mean-equations for curved flows. The effects on momentum and heat transfer in boundary layers are noticeable on typical wing sections and are very important on highly-cambered turbomachine blades. turbulence may be nearly eliminated on highly-convex surfaces, while on highly-concave surface momentum transfer by quasi-steady longitudinal vortices dominates the ordinary turbulence processes. The greatly enhanced mixing rates of swirling jets and the characteristic non-turbulent cores of trailing vortices are also consequences of the effects of streamline curvature on the turbulence structure. Author

N74-18923# Advisory Group for Aerospace Research and Development, Paris (France).
AERODYNAMIC INTERFERENCE INDUCED BY REACTION CONTROLS
F. W. Spaid (McDonnell Douglas Corp., Huntington Beach, Calif.), L. A. Cassel (McDonnell Douglas Corp., Huntington Beach, Calif.) and R. E. Wilson, ed. (Naval Ordnance Lab., White Oak, Md.) Dec. 1973 66 p refs
(AGARDograph-173; AGARD-AG-173) Avail: NTIS HC $6.50

The literature pertaining to the interaction of a sonic or supersonic gaseous jet with a transverse external flow has been reviewed. The flowfields associated with these interactions are complex, and knowledge of them is based largely on results of experiments. Numerous examples of data from flatplate experiments are presented. These include static pressure distribution, induced forces, flowfield survey, and flow visualization results. Analyses and correlation techniques for jet interaction flows are discussed. The region upstream of a jet in two dimensional flow is similar to the flow upstream of a forward-facing step, and the flow associated with a jet from a circular nozzle in a flat plate resembles the flow past a blunt nosed slender body. The single most important variable in determining the scale of these interactions is the ratio of jet momentum flux to the external flow dynamic pressure. When the external flow is subsonic, the interaction is sensitive to external flow Mach number in the high subsonic Mach number range and to the ratio between jet and external flow velocity in the low Mach number range. Author

N74-18924# Advisory Group for Aerospace Research and Development, Paris (France).
DIGITAL TECHNIQUES IN TURBULENCE RESEARCH
C. H. Gibson (Calif. Univ., La Jolla) and P. A. Libby, ed. (Calif. Univ.) Dec. 1973 30 p refs
(Contracts DAHC04-72-C-0037; N00014-69-A-0200-6006; N00014-69-A-0200-6039; Grant NSF GA-28366)
(AGARDograph-174; AGARD-AG-174) Avail: NTIS HC $4.50

Rapid advances in electronic information processing capabilities are providing powerful tools for turbulence research. Massive quantities of experimental information are necessary to characterize most turbulent flows, given the primitive nature of theoretical understanding in the field. Analytical treatments are equally dependent on powerful high speed computers to cope with the most truncated form of the full turbulence problem. Author

N74-22914# Advisory Group for Aerospace Research and Development, Paris (France).
ADVANCES IN NUMERICAL FLUID DYNAMICS
Feb. 1973 146 p refs
(AGARD-LS-64) Avail: NTIS HC $10.50

Lectures are presented on the theory of numerical stability for linear and nonlinear hyperbolic and parabolic equations, fundamental aspects of integration procedures for nonlinear flow

problems including shocks by finite difference techniques, and fundamental concepts extensions, and generalizations of the finite element methods. For individual titles, see N74-22915 through N74-22921

N74-22915 Uppsala Univ (Sweden) Dept of Computer Sciences
BOUNDARY CONDITIONS FOR DIFFERENCE APPROXIMATION OF HYPERBOLIC DIFFERENTIAL EQUATIONS
Heinz Otto Kreiss *In* AGARD Advan in Numerical Fluid Dyn Feb 1973 13 p refs (For availability see N74-22914 14-12)
Time dependent problems involving the processes of wave propagation and diffusion are dealt with. Solutions are given for calculating the boundary conditions and the difference approximation for hyperbolic differential equations in one space dimension. Separate solutions are shown for equations in more than one space dimension D L G

N74-22916 New York Univ, N Y Courant Inst of Mathematical Studies
NONLINEAR TIME DEPENDENT PROBLEMS IN FLUID DYNAMICS
Samuel Z Burstein *In* AGARD Advan in Numerical Fluid Dyn Feb 1973 20 p refs (For availability see N74-22914 14-12)
Three nonlinear problems in inviscid fluid dynamics are discussed. First we consider unforced finite amplitude vibrations of an undamped gas in a resonant cavity. The effect of amplitude on the vibrational frequency and wave shape is obtained by numerical integration of the complete nonlinear equations. The second problem is a nonlinear vibration problem with finite amplitude motion generated by a thermal forcing function. The forcing function is represented by a dilute spray of combustible fuel droplets in an oxidizing environment. In the last problem a computation in transonic flow is described Author

N74-22917 Von Karman Inst for Fluid Dynamics, Rhode-Saint-Genese (Belgium)
NUMERICAL INTEGRATION OF NAVIER-STOKES EQUATIONS
H J Wirz and J J Smolderen *In* AGARD Advan in Numerical Fluid Dyn Feb 1973 13 p refs (For availability see N74-22914 14-12)
The Eularian form of the Navier-Stokes equations is analyzed. A system of partial differential equations is obtained by expressing the conservation of mass, momentum, and energy in Eularian coordinates. Several categories of boundary conditions are considered together with selected discretization methods. The requirements of convergence, consistency, and stability are dealt with as well as the aspects of accuracy and error bounds D L G

N74-22918 Technische Hochschule, Aachen (West Germany) Aerodynamisches Inst
NUMERICAL TREATMENT OF BOUNDARY-LAYER PROBLEMS
Egon Krause *In* AGARD Advan in Numerical Fluid Dyn Feb 1973 21 p refs (For availability see N74-22914 14-12)
Finite difference solutions for three-dimensional compressible laminar and incompressible turbulent boundary layers are discussed in detail. Several finite difference approximations are introduced with their respective stability limits as obtained from a linearized stability analysis and numerical calculation. The importance of the domain of dependence and the region of influence in three dimensional boundary layers is elucidated. The equations of motion are given in orthogonal and non-orthogonal coordinates. A discussion of surface and external flow orientated system of coordinates is included. For turbulent flows the eddy viscosity concept expressed through a mixing length is adopted for the description of the turbulent shear stresses. Three different approximations used in the recent literature for closure assumptions are compared with the transport equations for the components of the turbulent shearing stress in three dimensional flows as given by Bradshaw. The finite difference solution employed is an implicit one which does not require additional assumptions for the laminar sublayer. Second and fourth order finite difference approximations enable acceptable computation times. Several results of sample calculations demonstrate the application of the method presented Author

N74-22919* National Aeronautics and Space Administration Ames Research Center, Moffett Field, Calif
SURVEY OF COMPUTATIONAL METHODS FOR THREE-DIMENSIONAL SUPERSONIC INVISCID FLOWS WITH SHOCKS
R W MacCormack and R F Warming *In* AGARD Advan in Numerical Fluid Dyn Feb 1973 20 p refs (For availability see N74-22914 14-12)
Hyperbolic systems of partial differential equations governing supersonic inviscid flows are discussed and analyzed. Finite-difference analogues for integrating these systems in the interior of fluid domains are described from two points of view: a differential form approach and an integral form approach. The algorithms presented are analyzed for stability and accuracy. The concept of time splitting is discussed and supplied to these methods to achieve increased numerical efficiency. Techniques for treating conditions at the boundaries of the fluid domain and shock-wave discontinuities at surfaces within the domain are described Author

N74-22920 General Dynamics/Astronautics, San Diego, Calif Aerospace Div
A SURVEY OF COMPUTATIONAL METHODS FOR 2D AND 3D TRANSONIC FLOWS WITH SHOCKS
H Yoshihara *In* AGARD Advan in Numerical Fluid Dyn Feb 1973 35 p refs (For availability see N74-22914 14-12)
More recent developments in the calculation of steady transonic flows with shocks using the finite difference procedure are reviewed. For the planar case the unsteady procedure of Magnus-Yoshihara (exact) and the steady relaxation procedures of Murman-Cole (small disturbance), Garabedian-Korn (exact) and Jameson (exact) are described, stressing their viability particularly in terms of their ability to capture the embedded shocks properly. Numerous examples are presented. The review is then concluded by a description of several axial symmetric and three dimensional calculations carried out by NASA Author

N74-22921 Edinburgh Univ (Scotland) Fluid Mechanics Unit
NUMERICAL TREATMENT OF FLUID DYNAMICAL STABILITY PROBLEMS
M A S Ross *In* AGARD Advan in Numerical Fluid Dyn Feb 1973 24 p refs (For availability see N74-22914 14-12)
Various theories are reviewed which led up to the modified Rayleigh model for finite amplitude disturbances. The derivation and properties of the Orr-Sommerfeld equation are given along with applications for parallel flows bounded by solid walls, plane poiseuille flow and eigenfunction expansions. Published numerical methods and models for the development of turbulence are reviewed which include implicit methods, explicit methods, single function methods, parallel function methods, and the treatment of orthonormalization D L G

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13 GEOPHYSICS

Includes aeronomy upper and lower atmosphere studies. oceanography, cartography, and geodesy. For related information see also 20 Meteorology, 29 Space Radiation, and 30 Space Sciences.

N72-25346# Advisory Group for Aerospace Research and Development, Paris (France).
NOMENCLATURE OF TERRAIN COLOUR
I. C. Perry (Headquarters Army Aviation Centre, Middle Wallop, Engl.) Mar. 1972 9 p In ENGLISH, partly in FRENCH Original contains color illustrations
(AGARD-AG-159, AGARDograph-159) Avail NTIS HC $3.00
A simple method by which color may be universally identified is described and illustrated. The system is designed to function as a precise color identification scheme regardless of language translation or individual interpretation. Such a system is important in air-ground communications of aircraft and spacecraft and various other scientific endeavors where exactness is necessary. E.H.W.

N73-22?50# Advisory Group for Aerospace Research and Development, Paris (France).
TOTAL ELECTRON CONTENT AND SCINTILLATION STUDIES OF THE IONOSPHERE
Jules Aarons, ed. (AFCRL) Mar. 1973 112 p refs
(AGARD-AG-166, AGARDograph-166) Avail NTIS HC $7.75
The current state of knowledge of ionospheric total electron content is outlined with special emphasis placed on the North Atlantic region of the world due to NATO special requirements in this region. A numerical model of total electron content, valid over the European continent under certain conditions, is presented for systems engineering use for an average background total electron content correction. Typical values of total electron content are also given at various locations in the high, middle and equatorial latitudes. With more observational data being taken at many locations, an overall satisfactory picture of the world wide behavior of this important parameter is beginning to emerge. Author

N74-14084# Advisory Group for Aerospace Research and Development, Paris (France).
NUMERICAL MODELS OF TOTAL ELECTRON CONTENT OVER EUROPE AND THE MEDITERRANEAN AND MULTI STATION SCINTILLATION COMPARISONS
John A. Klobuchar (AFCRL) and Jules Aarons (AFCRL) Nov. 1973 50 p refs
(AGARD-AG-166A; AGARDograph-166A) Avail NTIS HC $4.50
A numerical model of the total electron content over Europe for sunspot minimum conditions was described and a complete computer subroutine of the model is given. A TEC model value was obtained from the subroutine by specifying a season for one of the solar flux conditions contained in the model, a geographic latitude and a local time. Computer drawn isocontours of the original TEC data are shown along with contours of the model output. For individual titles see N74-14085 through N74-14088.

N74-14085 Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass. Ionospheric Physics Lab.
A NUMERICAL MODEL OF TEC OVER EUROPE FOR SUNSPOT MINIMUM CONDITIONS 2
John A. Klobuchar *In* AGARD Numerical Models of Total Electron Content over Europe and the Mediterranean and Multi Station Scintillation Comparisons Nov. 1973 p 2-15 refs (For availability see N74-14084 05-13)
The complete model computer program is given, along with the coefficients necessary to determine TEC at any local time and latitude for each of nine different seasons. Also shown are computer drawn isocontours, redrawn from the original data, and isocontours of the model output for each season. Author

N74-14086 Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass. Ionospheric Physics Lab.
A NUMERICAL MODEL OF TEC OVER THE MEDITERRANEAN AREA
John A. Klobuchar *In* AGARD Numerical Models of Total Electron Content over Europe and the Mediterranean and Multi-Station Scintillation Comparisons Nov. 1973 p 16-22 (For availability see N74-14084 05-13)
A numerical computer program subroutine model of the total electron content (TEC) of the ionosphere over the Mediterranean area was constructed using mean seasonal data taken at Athens, Greece. Data for four seasons are available and a separate numerical model representation of the data was made for each season. The TEC of the ionosphere produces an additional delay in the travel time of radio waves over their free space velocity. Thus, a numerical representation of this additional time delay can be useful in planning and operating such systems. Author

N74-14087 Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass. Ionospheric Physics Lab.
MULTI-STATION OBSERVATIONS, NOVEMBER 1971 - MARCH 1972
Jules Aarons *In* AGARD Numerical Models of Total Electron Content over Europe and the Mediterranean and Multi-Station Scintillation Comparisons Nov. 1973 p 24-29 refs (For availability see N74-14084 05-13)
In November 1971, observations of the 136 MHz beacon of Intelsat 2F2 became possible in Western Europe. With the advent of multistation observations in Western Europe, a comparison of middle to low latitude data became feasible. Author

N74-14088 Air Force Cambridge Research Labs., L. G. Hanscom Field, Mass. Ionospheric Physics Lab.
THE EFFECT OF THE AUGUST 1972 MAGNETIC STORMS ON SCINTILLATION
Jules Aarons and Eileen Martin (Emmanuel Coll.) *In* AGARD Numerical Models of Total Electron Content over Europe and the Mediterranean and Multi-Station Scintillation Comparisons Nov. 1973 p 30-44 ref (For availability see N74-14084 05-13)
During the period 2 August to 10 August 1972, a series of flares on the sun triggered another series of geophysical events. The resulting magnetic storms were of great intensity with K sub p reaching values of 9, the maximum index, twice. The effect on scintillations is of interest in two ways. First, it provides a worst case period so that a long time interval can be analyzed. Secondly, it provides a test for the descriptive model. Author

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14 INSTRUMENTATION AND PHOTOGRAPHY

Includes design, installation, and testing of instrumentation systems, gyroscopes, measuring instruments and gages, recorders, transducers, aerial photography, and telescopes and cameras

N71-20002# Advisory Group for Aerospace Research and Development Paris (France)

A LITERATURE SURVEY ON THE GYROSCOPE AND ITS APPLICATIONS

Helmut Sorg (Stuttgart Univ.) Feb 1971 23 p refs
(AGARD 582 71) Avail NTIS

A consolidated listing is presented of all known unclassified texts which are readily available to scientists and engineers from commercial sources, documentation centers and public as well as corporate libraries. Each entry cites the author publication year, title, documentation center source and a brief abstract of the work. Author

N71-36776# Advisory Group for Aerospace Research and Development, Paris (France)

RELIABILITY OF AVIONICS SYSTEMS

Jul 1971 191 p refs Mostly in ENGLISH, partly in FRENCH Conf held in Rome, 16-17 Sep 1971 and London, 20-21 Sep 1971. Sponsored by Avionics Panel and Exchange Programme of AGARD *Its* Lecture Series No 47
(AGARD-LS-47-71) Avail NTIS

CONTENTS

N71-36777# McDonnell Aircraft Corp., St Louis, Mo. Engineering Reliability

TECHNIQUES OF SYSTEM RELIABILITY ESTIMATION, INCLUDING FAILURE EFFECT ANALYSIS (FAILURE CONSEQUENCE)

W. T Sumerlin *In* AGARD Reliability of Avionics Systems Jul 1971 29 p refs (See N71-36776 23-14)
Avail NTIS

The reliability estimation of an avionic system, which includes gross estimates, rapid estimates, and detailed estimates is discussed. Probability of attainment is then studied by selective reliability allocation among subsystems, followed by feasibility estimates based on experience, complexity, failure rate summations and/or other effective techniques. Constraints including allowable degradation, alternative mode operation, environment, operator effectiveness, and excellence of maintenance will permit improved estimates. Failure mode and effect analyses serves to guide conceptual design decisions so as to eliminate single point failures and identify areas for judicious application of redundancy, requirements for high reliability parts, special environmental control, and beneficial choice of operating profile. Author

N71-36778# Radio Corp of America, Moorestown, N J

CORRELATION BETWEEN ESTIMATION TESTS AND SYSTEM OPERATING DATA

M M Tall *In* AGARD Reliability of Avionics Systems Jul 1971 9 p refs (See N71-36776 23-14)
Avail NTIS

The relationships between estimation tests and operational reliability are studied by regression analysis. The analysis includes equipment complexity and average mission length. Eleven equipment pieces were tested and results show that in several cases the reliability surpassed goals established for the tests. Results also indicate the tests may be used to refine the designs and remove defects introduced by parts, materials, and manufacture. Only avionic systems are used for the tests. E.H.W.

N71-36779# McDonnell Aircraft Corp., St. Louis, Mo Engineering Reliability

EFFECTIVENESS OF RELIABILITY PROGRAM ELEMENTS

W T Sumerlin *In* AGARD Reliability of Avionics Systems Jul 1971 9 p (See N71-36776 23-14)
Avail NTIS

An opinion is given of the probable relative importance of reliability program elements including reliability requirement evaluation and allocation, proof of attainment, parts control, design surveillance, failure analysis and design correction, and reliability progress measurement. Author

N71-36780# Radio Corp of America, Moorestown, N J

COST EFFECTIVENESS OF BUILT-IN TEST PROVISIONS

M M Tall *In* AGARD Reliability of Avionics Systems Jul 1971 8 p refs (See N71-36776 23-14)
Avail NTIS

The feasibility of using built in test provisions (BIT) as a means of improving operational effectiveness of aircraft is discussed. The primary purpose of BIT is to indicate to the user if the prime equipment is operating satisfactorily. It provides information upon which a decision to abort, modify or continue a mission may be based. Bit may also be applied to passive devices. In highly complex equipment BIT may indicate degrade

performance of portions of the equipment as well as catastrophic failure, and indicate the use of any alternate mode of operations. The cost effectiveness of BIT is also discussed E.H.W.

N71-36781# Grumman Aerospace Corp., Bethpage, N.Y. Engineering Operations and Administration
HIGH RELIABILITY DESIGN TECHNIQUES APPLIED TO THE LUNAR MODULE c15
J. J. Bussolini *In* AGARD Reliability of Avionics Systems Jul. 1971 34 p refs (See N71-36776 23-14)
Avail: NTIS

A description is given of the significant design techniques applied to the lunar module to attain system reliability. The use of system work-arounds, functional redundancy, hi-rel parts screening, successive stage building block testing, vehicle testing, overstress testing, failure mode and effect analysis and many other techniques are described, illustrating their relative importance toward the success of the program Author

N71-36782# Siemens-Schuckertwerke A. G., Munich (West Germany).
TESTING THE RELIABILITY OF AVIONIC EQUIPMENT FOR SPACECRAFT APPLICATIONS
Guenter Vollhardt *In* AGARD Reliability of Avionics Systems Jul 1971 10 p (See N71-36776 23-14)
Avail: NTIS

To ascess the stress limits and failure modes of spacecraft equipment, models were constructed and tested under various stresses and environmental conditions. The tests show failure to be caused by errors in mechanical or electrical design and drift of electrical and mechanical parts. Circuit analyses as well as mechanical and climatic tests were conducted E.H.W.

N71-36783# Grumman Aerospace Corp Bethpage, N.Y. Engineering Operations and Administration
METHODS OF SPECIFYING AND CONTROLLING DESIGN RELIABILITY
J. J. Bussolini *In* AGARD Reliability of Avionics Systems Jul. 1971 19 p refs (See N71-36776 23-14)
Avail: NTIS

Some examples of techniques used to accomplish early determination of system and equipment reliability requirements, the methods use to specify these requirements and the contractual techniques used to test and demonstrate compliance to specification requirements are examined. Incentive--penalty contracting for reliability is discussed including recommendations for relating these incentives and penalties to conventional and modified demonstration test techniques Author

N71-36784# Radio Corp of America, Moorestown, N.J.
RELATIONSHIPS BETWEEN PROGRAM TEST AND USER SUPPORT COSTS
M. M. Tall *In* AGARD Reliability of Avionics Systems Jul 1971 9 p refs (See N71-36776 23-14)
Avail: NTIS

The significant factors that should be included in a cost ownership analysis of avionic equipments are discussed. The value of reliability improvement efforts, including AGREE type test programs, are assessed Author

N71-36785# McDonnell Aircraft Corp. St Louis, Mo Engineering Reliability
SYSTEM OPERATIONAL CONSIDERATIONS AND THEIR RELATIONSHIP TO THE TEST PROCESS
W. T. Sumerlin *In* AGARD Reliability of Avionics Systems Jul 1971 8 p refs (See N71-36776 23-14)
Avail: NTIS

Indicators for raising the reliability of a system hardware unit through burn in tests, failure analysis, and corrective design changes, are discussed. Mean time between failure (MTBF) is used as an index of reliability to describe the operational requirements and to relate these requirements to tests and verification observations. The limitations and constraints of MTBF are also discussed E.H.W.

N71-36786*# Centre National d'Etudes des Telecommunications, Lannion (France)
TECHNIQUES OF ANALYZING ACCELERATION [LA TECHNIQUE DES ESSAIS ACCELERES]
P. Blanquart *In* AGARD Reliability of Avionics Systems Jul 1971 18 p In FRENCH (See N71-36776 23-14)
Avail: NTIS

The reliability of electronic components after acceleration tests is discussed. The effects of vibration, humidity, and temperature on degradation are considered. Mathematical models and regression analysis are also discussed E.H.W.

N71-36787# Grumman Aerospace Corp Bethpage, N.Y. Engineering Operations and Administration
THE BENEFITS OF A TOTALLY INTEGRATED RELIABILITY TEST PROGRAM
J. J. Bussolini *In* AGARD Reliability of Avionics Systems Jul 1971 21 p refs (See N71-36776 23-14)
Avail: NTIS

The benefits derived from a totally integrated test program in terms of cost, schedule, and resultant system reliability are discussed Author

N71-36788# Royal Air Force, High Wycombe (England) Strike Command
OPERATIONAL CONSIDERATIONS AND SYSTEMS RELIABILITY
B. E. Baker *In* AGARD Reliability of Avionics Systems Jul 1971 7 p (See N71-36776 23-14)
Avail: NTIS

The problem of deciding what reliability to specify and how to ensure that this reliability is achieved is discussed. An example is given of trade-offs between reliability and maintainability and performance parameters. The need for a formal reliability program is stressed and parts of this are discussed in detail. The value of reliability testing at the end of development is illustrated by a costed example Author

N71-36789# Sandia Labs., Albuquerque, N Mex
HIGH INTENSITY DIRECT READING HEAT FLUX GAUGE
H. C. Hardee and A. B. Donaldson Apr 1971 9 p refs
Sponsored by AEC
(SC-DR-710194) Avail: NTIS

A high intensity direct reading heat flux gauge is described. The device can be used under a wide variety of field test conditions. The gauge is a quasi-steady state type and offers advantages over both the steady-state and the transient types. Because the signal output is directly proportional to the incident heat flux, data reduction errors are minimized. The device has the capability of a secondary, transient type measurement which provides a check on the primary measurement. A lab test was conducted in which the measurements obtained from the direct reading gauge were compared with measurements obtained from a calibrated steady-state gauge Author (NSA)

N72-19483# Advisory Group for Aerospace Research and Development, Paris (France)
AVIONICS IN SPACECRAFT
Ph. Hartl and John E. Twirn, eds Sep 1971 349 p refs
Proc of the 220 Tech. Symp. of the Avionics Panel of AGARD, Rome, 31 May-4 Jun 1971
(AGARD-CP-87-71) Avail: NTIS HC $6.00 MF $0.95

The proceedings of a conference on avionics for spacecraft are presented. Subjects discussed are (1) microelectronic equipment (2) semiconductor devices (3) attitude control systems (4) remote sensors (5) data processing equipment (6) satellite communications and (7) design of telemetry and telecommand

links for interplanetary space probes A total of 31 papers was presented For individual titles, see N72-19484 through N72-19514

N72-19484# Air Force Systems Command, Wright-Patterson AFB Ohio Air Force Avionics Lab
MICROELECTRONICS FOR AEROSPACE SYSTEMS
H V Noble *In* AGARD Avionics in Spacecraft Sep 1971 11 p refs (See N72-19483 10-14)
Avail NTIS HC $6.00/MF $0 95
The reasons for the entry of the USAF into microelectronics, some significant recent achievements, and predictions of microelectronic devices that will be available for aerospace systems for the 1975-1980 time period are presented These predictions are based on the extension of advances made during the past few years plus estimates of results of current and future USAF programs. The following types of devices are covered (1) digital and analog circuit devices for computer and data processing (2) integrated microwave devices for both receivers and transmitters, (3) integrated circuit devices for high data rate transmission, (4) integrated circuit - antenna arrays, and (5) size reduction possibilities for computers based on use of advanced microcircuits Author

N72-19485# Royal Aircraft Establishment, Farnborough (England) Space Dept
HYBRID MICROCIRCUIT TECHNOLOGY IN THE BRITISH NATIONAL SPACE PROGRAM
H D Fisher *In* AGARD Avionics in Spacecraft Sep 1971 15 p refs (See N72-19483 10-14)
Avail NTIS HC $6 00/MF $0 95
Experimental equipment to be flown on the X3 satellite in the British national space program is discussed Arguments are presented in support of the use of hybrid microcircuits for very high quality, low volume production of electronic circuits The current techniques are described and reasons for the choice of technologies are given Process and component yields are examined Author

N72-19486# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany)
CIRCUIT DESIGN FOR SPACECRAFTS WITH COMPLEMENTARY MOS INTEGRATED CIRCUITS
W Schambeck *In* AGARD Avionics in Spacecraft Sep 1971 10 p refs (See N72-19483 10-14)
Avail NTIS HC $6 00/MF $0 95
The application of complementary metal oxide semiconductors (C-MOS) to spacecraft and commercial equipment is discussed The use of C MOS for electronic clocks and portable instrumentation is described The advantages resulting from low power dissipation and high circuit flexibility of C-MOS circuits are examined Some of the special considerations required in the design and operation of C-MOS circuits are explained Author

N72-19487# Communications Research Centre Ottawa (Ontario)
AN IMPROVED APPROACH TO SELECTION OF HIGH RELIABILITY SEMICONDUCTOR COMPONENTS FOR SATELLITE PROGRAMS
A R Molozzi and R F Haythornthwaite *In* AGARD Avionics in Spacecraft Sep 1971 7 p (See N72 19483 10-14)
Avail NTIS HC $6.00 MF $0 95
Selection procedures to improve the quality of semiconductor devices used on the Alouette ISIS satellite program are discussed The lack of reliability inherent in mass production of semiconductors and the impact on the design of satellites with five to ten year life span is described The method for choosing semiconductor devices in order to obtain maximum component reliability is presented The interrelation of circuit design and component selection is examined Author

N72-19488# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany) Inst fuer Satellitenelektronik
SOME NOVEL METHODS IN FAILURE ANALYSIS
E Ress and G Ress *In* AGARD Avionics in Spacecraft Sep 1971 12 p refs (See N72-19483 10-14)
Avail NTIS HC $6 00 MF $0 95
Methods of conducting failure analysis of integrated circuits are discussed The application of scanning electron microscopy for nondestructive tests in failure analysis is described The modes in which the scanning electron microscope is used are presented The types of failures which the scanning electron microscope is capable of detecting are described Author

N72-19489# Montecatini Edison S p A , Milan (Italy)
INTEGRATED CHECK-OUT SYSTEM FOR SPACE LAUNCHERS AND AIRCRAFT SYSTEMS
Mauro Falleni *In* AGARD Avionics in Spacecraft Sep 1971 16 p refs (See N72-19483 10-14)
Avail NTIS HC $6 00/MF $0 95
A completely integrated system capable of performing all the necessary operations for the check-out of space launchers of the 1970's generation and for aircraft systems is described It is to be considered as a general purpose system Any kind of real-time operation necessary for check-out operations and all the post-flight computation can be carried on without external aids The general philosophy of its conception is such that certain attributes such as simplicity, modularity, minimum specialization allow for the widest possibility of efficiency and expansion possibly required for future, more elaborated check out procedures A number of degraded levels of operation is allowed, the lowest of them being the manual operation level, in order to face different emergency situations Special consideration has been given to the man-machine relationships and to the efficiency of maintenance and repair operations Author

N72-19490# Montecatini Edison S p A , Milan (Italy)
CONSIDERATIONS ON A SUBSYSTEM FOR HANDLING COMMANDS AND STIMULI FOR AN INTEGRATED AND AUTOMATIC CHECK OUT OF SPACE LAUNCHERS
Mauro Falleni *In* AGARD Avionics in Spacecraft Sep 1971 19 p refs (See N72 19483 10-14)
Avail NTIS HC $6 00 MF $0 95
A description of the stimuli and commands subsystem for the EUROPA 3 launch vehicle is presented A description of the organization and functions of the system is given Data transmission format and message structure are examined The required circuits for handling the data flow are presented Problems concerning the reliability of transmitting and executing a stimulus and/or a command are analyzed and partially solved Other aspects of the interfaces between this subsystem and the other part of either the checkout system or the vehicle have been considered and solved in reasonable detail Author

N72-19491# Philips Gloeilampenfabrieken N V Geldrop (Netherlands)
ANS ATTITUDE CONTROL SUB-SYSTEMS
P VanOtterloo *In* AGARD Avionics in Spacecraft Sep 1971 10 p (See N72 19483 10 14)
Avail NTIS HC $6 00 MF $0 95
The attitude control subsystem and onboard computer for the ANS satellite are discussed The ANS is an astronomical satellite for ultraviolet and X-ray measurements in space A description of the satellite is presented The requirements of the attitude control subsystem and the onboard computer are analyzed The subsystems are described and their various modes of operation are examined Author

N72-19492# Selenia S p A , Rome (Italy)
THREE AXIS R F ATTITUDE SENSOR OF A GEOSTATIONARY SATELLITE
Benito Palumbo *In* AGARD Avionics in Spacecraft Sep 1971

17 p (See N72-19483 10-14)
Avail NTIS HC $6.00/MF $0.95

A three axis radio sensor for satellite application is described. The system measures the attitude error of a three-axis stabilized geostationary satellite with respect to an earth station that transmits a RF beacon signal. A phase comparison two-dimensional system on-board the satellite is used for measuring the pitch and roll errors. The error around the yaw axis is obtained by comparing the orientation of the linear polarization of the on-board antennas with the polarization plane of the ground transmitted signal. The system and the design criteria of the components are presented. The pointing error sources are analysed and the accuracy of the system is evaluated. The required characteristics of the ground station are indicated with reference to the system operation. Author

N72-19493# Teldix Luftfahrt-Ausruestungs G.m.b.H., Heidelberg (West Germany)
THE DRALLRAD: A FLYWHEEL FOR THE STABILIZATION OF SYNCHRONOUS SATELLITES
Heinz Wehde *In* AGARD Avionics in Spacecraft Sep. 1971 7 p (See N72-19483 10-14)
Avail NTIS HC $6.00/MF $0.95

The application and operation of flywheels for stabilization of synchronous satellites is discussed. Optimal relations between angular momentum, size, and weight are calculated. Rules for the use of ball bearings are established. The characteristics of a brushless, dc motor with optical commutation and permanent magnet excitation are described. The electrical and mechanical results obtained from various configurations are summarized. Author

N72-19494# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)
ELECTRONICS OF A MASS SPECTROMETER
V. Gerber *In* AGARD Avionics in Spacecraft Sep. 1971 7 p (See N72-19483 10-14)
Avail NTIS HC $6.00/MF $0.95

A quadrupole mass spectrometer consisting of an ion source, mass analyzer, multiplier, and associated electronics is described. The mass spectrometer will measure the absolute abundances of neutral atmospheric constituents and the relative composition of ambient ions. The various atmospheric parameters which can be determined by combined data from the mass spectrometer, impedance probe, retarding potential and neutral atmospheric temperature experimants are discussed. Author

N72-19495# Marconi Space and Defence Systems, Ltd., Frimley (England)
METHODS OF IDENTIFICATION OF THE EARTHS HORIZON AND EXAMPLES OF APPLICATION TO ATTITUDE DETERMINATION OF SPACECRAFT
G. G. Fuller and M. L. Reynolds *In* AGARD Avionics in Spacecraft Sep. 1971 9 p refs (See N72-19483 10-14)
Avail NTIS HC $6.00/MF $0.95

The attitude determination of earth orbiting satellites by sensing earth radiation is discussed. Various classes of missions and their relation to the different classes of earth sensors are examined. The earth's radiant field for visible and middle infared wavelengths is described. Examples of several missions are presented and the sensors designed to fulfill the requirements of each mission are analyzed. Author

N72-19496# Officine Galileo S.p.A., Florence (Italy)
SENSORS OF THE EARTH INFRARED HORIZON AND SOLAR SENSORS FOR SATELLITE ATTITUDE DETERMINATION
R. Baldassini Fontana *In* AGARD Avionics in Spacecraft Sep. 1971 10 p refs (See N72-19483 10-14)
Avail NTIS HC $6.00/MF $0.95

An analysis is presented of a sensor system to be placed on board of a geostationary spinning satellite for the purpose of determining the satellite attitude during the transfer and final orbit. The system consists of sensors of earth infrared horizon and sun sensors. The magnitudes to be observed and the type of information to be obtained in connection with the operational conditions, are analyzed. In addition, the results of the computations developed to optimize the parameters of the sensors and to establish the system accuracy, are described. Author

N72-19497# Officine Galileo S.p.A., Florence (Italy)
SCANNING RADIOMETERS FOR METEOROLOGICAL SATELLITE
V. Rizzo *In* AGARD Avionics in Spacecraft Sep. 1971 11 p refs (See N72-19483 10-14)
Avail NTIS HC $6.00/MF $0.95

The characteristics of imaging radiometers for mechanical scanning from a satellite platform in the infrared and visible spectra are discussed. A survey of the experimental objectives and their influence on the choice of spectral band to be used is presented. The trade-off between quality of picture and physical properties of the radiometer are examined. A typical instrument is shown in order to describe the nature of its operation. Author

N72-19498# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)
SATELLITE TELEVISION SYSTEM
O. Hofmann *In* AGARD Avionics in Spacecraft Sep. 1971 11 p refs (See N72-19483 10-14)
Avail NTIS HC $6.00/MF $0.95

The operating principles of a satellite television recording system with no moving mechanical parts are presented. The television recording is performed by continuous line scanning with constantly open aperture. The scanning line is divided by several mirror strips and led to vidicons. By insertion of prisms the line sections can be dispersed spectrally. The essential characteristics of the system with emphasis on stereoscopic recording are described. Author

N72-19499# Royal Aircraft Establishment, Farnborough (England)
AN EXPERIMENTAL CANOPUS STAR SENSOR
P. Haskell *In* AGARD Avionics in spacecraft Sep. 1971 13 p refs (See N72-19483 10-14)
Avail NTIS HC $6.00/MF $0.95

The Canopus star sensor and its application to the stabilization of the X4 technology satellite are discussed. The modes of operation performed by the spacecraft to check the parameters of the sensor are explained. Subsidiary experiments which may be conducted by the sensor during the mission are examined. Author

N72-19500# Lincoln Lab., Mass. Inst. of Tech., Lexington
THE USE OF VISIBLE LIGHT SENSORS IN SPINNING SATELLITE CONTROL SYSTEMS
F. Williams Sarles, Jr. *In* AGARD Avionics in Spacecraft Sep. 1971 8 p refs (See N72-19483 10-14)
Avail NTIS HC $6.00/MF $0.95

The application of visible light sensors in spinning satellite control systems launched during the Lincoln Experimental Satellite (LES) program is discussed. Earth location information use in either an intermittent or continuous sensing operation is described. It is concluded that an accuracy of one tenth of a degree should be realizable in circular, synchronous, near equatorial orbits. Author

N72-19501# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany)
THE APPLICATION OF COMPLEMENTARY MOS CIRCUITS IN PCM SYSTEMS AS A QUALIFICATION TEST
Manfred Mozer *In* AGARD Avionics in Spacecraft Sep. 1971 6 p refs (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

Two electronical devices, which are implemented with complementary MOS-circuits are described. One of these systems was part of an ESRO-payload, by the aid of which photographic and photometric measurements in the soft X-ray region had been carried out during a sounding-rocket flight. The aim of the experiment was an investigation of the sun corona. The electronical subsystem of the experiment had been developed for the measurement of the intensity of five emission-lines and for the convers on of these results into a PCM-signal. The second device is a quartz-clock with a PCM-output, which is installed in a recording current meter for an application in oceanography. It is specified for a very low power consumption and has to demonstrate the long-life qualities of complementary MOS-circuits for the undersea current meter is expected to have a lifetime of one year. Due to this long time and due to the necessity of low power consumption, the seaprobe is an ideal platform for a qualification test of components, which are provided for an application in spacecrafts. Though both devices have been developed as functional support for other experimenters, they are technological experiments of our institute and part of our activities, to test and to introduce new components. Author

N72-19502# Royal Aircraft Establishment, Farnborough (England) Space Dept.

DATA STORAGE FOR SMALL SCIENTIFIC SPACECRAFT

A. C. Christmas and A. H. Spooner *In* AGARD Avionics in Spacecraft Sep. 1971 5 p (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

The reasons for on-board data storage are considered together with the type of storage necessary. This covers spacecraft status, continuously changing experiments, survey or totalising experiments and the organization of data into a form which is suitable for storage. These considerations together with telemetry and ground receiver requirements effectively specify the performance of a data storage system. Practical examples are given showing how the requirements have been met. The development, testing and orbital performance of an endless loop tape recorder, including the mechanical techniques used to meet the reliability, power and flutter requirements are described. Future needs are considered and compared with possible developments to give a forecast of the type of data storage which will be employed in later spacecraft. Author

N72-19503# Royal Aircraft Establishment, Farnborough (England)

A MODULAR SPACECRAFT PCM DATA CONDITIONING SYSTEM

L. Smith and K. McDonald (Marconi Space and Defense Systems, Ltd.) *In* AGARD Avionics in Spacecraft Sep. 1971 17 p refs (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

The PCM system developed for encoding and formatting data on board spacecraft is described. A set of standard modules has been designed which can be arranged in various ways to meet the many demands presented by the program. Within each module components are welded either to a nickel wire or a nickle-mylar interconnection matrix and then encapsulated to form slim cards. These are assembled and wire-wrapped to a back panel to produce functional units such as an encoder or decoder. Integrated circuits, purchased to in-house specifications which call for 100% inspection at all stages of manufacture and test, have been used wherever possible. The system accepts data in 3 forms: (1) digital in parallel or (2) serial form, and (3) analogue in the range plus or minus 5 volts. The analogue data is converted into 8 bit words prior to insertion into the main data stream. The maximum rate is 8,000 samples/sec which corresponds to a bit rate of 64 kHz. System feasibility was demonstrated using a prototype model and this has been developed and engineered into fully operational X3 system. Author

N72-19504# Standard Elektrik Lorenz A. G., Stuttgart (West Germany)

PROGRAMMABLE PCM TELEMETRY ENCODER FOR SPACE APPLICATIONS

D. Pabst *In* AGARD Avionics in Spacecraft Sep. 1971 4 p (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

The function of the programmable PCM-Encoder in controlling the data handling necessary for transmission is discussed. The programmability has many advantages, since the specifications change from mission to mission. There are pre-wired and programmable functions. The generation of the control data will be achieved by a device within the encoder, very similar to a small computer. The program loading technique is compatible with nearly all command systems. The weight of an encoder is within the range of 1 to 3 kg, the power consumption varies from 1 to 4 watts depending on the bitrate. Author

N72-19505# Marconi Space and Defence Systems, Ltd., Portsmouth (England)

USE OF COMPUTERS FOR REAL TIME SATELLITE CHECKOUT

M. A. Skinner *In* AGARD Avionics in Spacecraft Sep. 1971 5 p (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

The application of computers for automatic testing and data processing during the checkout of satellites is discussed. The rationale for selecting a digital computer for data processing and automatic control is explained. The requirement for the checkout to encompass all performance parameters and the amount of time required form the basis for computer use. The skills required to produce and use a computer controlled checkout system are examined. Author

N72-19506# IBM Italia, Rome

AN APPROACH TO NATURAL LANGUAGE FOR COMMAND AND CONTROL SYSTEMS

A. Lanzara *In* AGARD Avionics in Spacecraft Sep. 1971 9 p refs (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

The development of a user-oriented language for effective man machine communication is discussed. The feasibility of such a language for command and control purposes is examined. Different language models are analyzed and the basis for selection is explained. The influence of batch processing and on-line processing on the selection of the appropriate language is described. Author

N72-19507# Lincoln Lab., Mass. Inst. of Tech., Lexington

A VARIABLE COVERAGE SATELLITE ANTENNA SYSTEM

A. R. Dion and L. J. Ricardi *In* AGARD Avionics in Spacecraft Sep. 1971 13 p refs (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

A multi-beam antenna system and combiner switch capable of producing a variable-coverage radiation pattern are described. The antenna consists of a waveguide lens illuminated by a 19-element feedhorn array. The combiner switch consists of a corporate arrangement of variable power dividers, the latter is made up of two phase shifters and two conventional hybrid power dividers. An earth-coverage radiation pattern with less than 2 dB ripple and an antenna gain of 20 dB is obtained by equally exciting all beams of the multi-beam antenna simultaneously. Excitation of a single feedhorn results in a narrow beam with an antenna gain of 30 dB and a near-in side lobe level less than minus 20 dB. The side-lobe level can be reduced appreciably by appropriately exciting the adjacent feedhorns. The frequency bandwidth corresponding to 0.5 dB decrease in antenna gain is 10 percent. A technique for computing the radiation properties of the antenna is described. Author

N72-19508# Deutsche Forschungs und Versuchsanstalt fuer Luft und Raumfahrt, Oberpfaffenhofen (West Germany)

DESIGN OF TELEMETRY AND TELECOMMAND LINKS FOR INTERPLANETARY SPACE PROBES

E Stolle *In* AGARD Avionics in Spacecraft Sep 1971 16 p refs (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

The concept of spacecraft/earth telecommunication links is presented, and various system parameters with their influence on link performance are discussed. Of particular interest are (1) power division between carrier and sidebands, (2) modulation indices, (3) demodulation/detection losses of RF receiver, (4) subcarrier demodulator, (5) bit synchronizer, (6) number of subcarriers, and parameter tolerances. The design criteria such as data rate, bit error rate, and spacecraft effective radiated power are discussed. An optimization method is given based on a criterion of minimum required total signal to noise ratio at the receiver. Examples from the link design for the HELIOS solar probe demonstrate the practicality of the approach. Author

N72-19509# Royal Aircraft Establishment, Farnborough (England)

SOME ASPECTS OF MULTIPATH FADING IN AERONAUTICAL SATELLITE SYSTEMS

M J Sidford *In* AGARD Avionics in Spacecraft Sep 1971 15 p refs (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

Information is presented which allows estimates to be made of the amplitudes and frequencies of the fades which occur in a satellite-to-aircraft radio link due to interference between the direct waves and the reflected from the earth's surface. A wide range of conditions is covered involving reflecting surface properties, frequency and polarisation of the radio waves, aircraft antenna radiation pattern, and satellite elevation angle. Experimental evidence of multipath fading over sea and ice is included and recommendations are made for the aircraft aerial characteristics required to reduce this fading. Author

N72-19510# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany)

RANGING TRANSPONDERS FOR INTERPLANETARY SPACE PROBES

H Bassenberg and R Stoiber *In* AGARD Avionics in Spacecraft Sep 1971 12 p (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

Different concepts such as direct amplification use of doublers and triplers in solid state power amplifiers at 2.3 GHz with power output up to 20 W are discussed. The important characteristics values of a doubler concept are measured with a test set up of 1.15 GHz stripline amplifier using the power transistor 2N5921. Furthermore versions of cavity and stripline doublers using varactors MA 43000, MA 4B 300, BXY 19 GB and stripline power dividers and combiners are discussed. Power chains connected in parallel make possible a 20 W amplifier at 2.3 GHz with a total efficiency of better than 30 percent. Author

N72-19511# Lincoln Lab, Mass Inst of Tech, Lexington

EFFICIENT X BAND POWER GENERATION FOR SATELLITE COMMUNICATIONS

D M Snider *In* AGARD Avionics in Spacecraft Sep 1971 9 p refs (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

The efficient generation of solid state X-band power by utilizing the negative impedance characteristics of avalanche diodes in reflection amplifiers is discussed. Circuits with low level gains of 13 db with 500 mc bandwidth are described. Power outputs of one watt continuous wave with 5 db gain and 20 percent conversion efficiency in the same circuit are examined. Gain response curves for gallium arsenide diodes are included. Author

N72-19512# Royal Aircraft Establishment, Farnborough (England)

MEASUREMENT OF ANTENNA RADIATION PATTERNS ON SPACECRAFT

A Stembridge *In* AGARD Avionics in Spacecraft Sep 1971 11 p (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

The measurement of antenna radiation patterns on spacecraft telemetry and telecommand antennas operating in the VHF (136 - 149 MHz) and UHF (435 - 470 MHz) frequency ranges is discussed. Measurements have been carried out on out-door ranges by full scale and model techniques which are described. Facilities for making measurements have been limited to models weighing less than 100 lb. A new facility, now under construction, using improved techniques and capable of handling models up to 500 lb in weight is described. General techniques and methods of presenting results are explained and typical antenna radiation patterns are given. Some comments on merits of anechoic chamber and out-door methods of measurement are made. Author

N72-19513# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

AUTOMATIC TRACKING OF Q-SWITCHED LASER RANGEFINDERS

Roland Moreau *In* AGARD Avionics in Spacecraft Sep 1971 12 p refs In FRENCH, ENGLISH summary (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

The automatic tracking of Q-switched laser rangefinders is discussed. Subjects presented are (1) programmed tracking through ephemerides, (2) independent tracking using cartometric data, and (4) semiautomatic tracking. The acquisition period for each system is studied with emphasis on twenty four hour satellites. The effect of the pulse frequency is analyzed when there is a partially random displacement of the target. Author

N72-19514# Royal Aircraft Establishment, Farnborough (England)

CHIRP MODULATION SYSTEM IN AERONAUTICAL SATELLITES

G W Barnes, D Hirst, and D J James *In* AGARD Avionics in Spacecraft Sep 1971 10 p (See N72-19483 10-14)

Avail NTIS HC $6.00/MF $0.95

The advantages of chirp modulation for air ground digital communication by way of geostationary satellites are described. The effectiveness in reducing multipath reception and Doppler frequency shifts is discussed. The contribution of chirp modulation to reducing the limitations of marginal power budgets on satellite to aircraft links is examined. Flight tests of experimental systems are included. Author

N72-25419# Advisory Group for Aerospace Research and Development, Paris (France)

GUIDANCE AND CONTROL DISPLAYS Technical Evaluation Report

H B Lyon Jr Mar 1972 9 p refs Presented at 13th Symp of AGARD Guidance and Control Panel

(AGARD AR 43) Avail NTIS HC $3.00

The principal disciplines involved in the designing of displays for guidance and control and the evolution of the design process were discussed. An evaluation is presented from three viewpoints in an attempt to provide a better understanding of the total conference. These are (1) general criteria (2) criteria for specific applications, and (3) new technology. Author

N72-25420# Advisory Group for Aerospace Research and Development, Paris (France)

FLIGHT TEST INSTRUMENTATION SERIES VOLUME 3 THE MEASUREMENT OF FUEL FLOW

J [illegible] France Mar 1972 32 p refs

(AGARDograph 160 Vol 3, AGARD AG 160 Vol 3) Avail NTIS HC $3.75

The main methods of fuel flow measurement are discussed and the prospective user is advised of the factors that should be considered in deciding which type of meter to use and what precautions to take in the installation. Details are given of the three main types of flowmeters in common use, namely turbine, orifice and angular momentum true mass. The theory of operation of each type of flowmeter is given together with details of accuracy, pressure drop, susceptibility to inlet and outlet conditions, form of output, and other key parameters likely to influence the choice of type of meter to be used. A quick reference summary is provided for the comparison of the performance of the three types of meter and various methods of calibrating flowmeters are discussed. A separate section is devoted to specialist flowmeters which are not in general use, but may have an application in flight test work. Particular emphasis is placed on solid state flowmeters which due to the need to obtain improved life and reliability, are the subject of much research work. Author

N72-32457# Advisory Group for Aerospace Research and Development, Paris (France)
FLIGHT RECORDING IN NATO COUNTRIES, SECOND EDITION
Hollis G. Zerkle, ed. Jul 1972 75 p refs
(AGARD-AR-39) Avail NTIS HC $5.75

The characteristics and applications of flight recording instruments in NATO countries is discussed. The instruments and systems are presented according to manufacturer and the standard format contains the following data: (1) general information, (2) scope, (3) basic principles, (4) main characteristics, (5) history, (6) operational experience, and (7) installation. Flight recording projects leading to the development of new instruments are discussed, using similar format. A bibliography of pertinent reports and documents on various aspects of flight recorder application and performance is provided. Author

N73-10450# Advisory Group for Aerospace Research and Development, Paris (France)
FLIGHT TEST INSTRUMENTATION
Sep 1972 76 p refs Partly in ENGLISH and partly in FRENCH (AGARD-LS-50) Avail NTIS HC $6.00

The impact of technological developments on improvements in the operating characteristics of flight test data systems is outlined. Special efforts were made to provide the non-engineer an outline of data acquisition processing systems and capabilities, a look at mathematical techniques for extracting data from recorded information and illustrate how these developments have influenced the design of flight test programs. For individual titles see N73-10451 through N73-10457

N73-10451 Boeing Co., Seattle, Wash. Commercial Airplane Group
FLIGHT TEST INSTRUMENTATION SYSTEMS OF THE 70'S
Alex J. Ferkovich *In* AGARD Flight Test Instrumentation Sep 1972 11 p (For availability see N73-10450 01-14)

The projected equipment, techniques, and procedures used in research flight test instrumentation systems are outlined. The impact of new technology on complex aircraft systems is discussed. E.H.W.

N73-10452 Advisory Group for Aerospace Research and Development, Paris (France)
AIRBORNE DATA ACQUISITION AND PROCESSING SYSTEMS
Alain Klopfstein *In its* Flight Test Instrumentation Sep 1972 12 p (For availability see N73-10450 01-14)

The evolution of the in-flight measurement system concept from the mere compatibility of instruments to overall airborne data handling and processing is considered as well as its impact on system structure. Illustrations are given of various types of equipment and systems and of their utilisation according to particular requirements. Author

N73-10453 Royal Aeronautical Society, London (England)
GROUND HANDLING TECHNIQUES AND SYSTEMS
J. M. L. Thomas *In* AGARD Flight Test Instrumentation Sep 1972 4 p (For availability see N73-10450 01-14)

The processing of data from large civil aircraft, particularly data from the Concorde's digital recordings, is discussed. Data cover digital magnetic tape for quasi-static parameters, FM magnetic tape for dynamic parameters, and film and paper tape for take off and landing measurements. E.H.W.

N73-10454 French Flight Test Center, Istres
DYNAMIC DATA PROCESSING SYSTEMS
M. B. Pennacchioni *In* AGARD Flight Test Instrumentation Sep 1972 18 p (For availability see N73-10450 01-14)

An analysis was made of the systems used to measure in flight, take off runs, or landing data. Data are given for system flexibility, ease of pre- and post- processing, ease of communication between user and machine, bulk of system, and cost of using the system. Consideration is also given to measuring range, sensitivity, and accuracy of the system. E.H.W.

N73-10455 Princeton Univ., N.J. Dept. of Aerospace and Mechanical Sciences
THE ANALYSIS OF STEADY STATE AND RANDOM FLIGHT DATA
E. J. Durbin *In* AGARD Flight Test Instrumentation Sep 1972 3 p (For availability see N73-10450 01-14)

The functional dependence of test time of random and deterministic flight data analysis is investigated. The investigation covers test planning, instrumentation technology, and data analysis techniques. E.H.W.

N73-10456 Arizona State Univ., Tempe. Lab. for Measurement Systems Engineering
A UNIFIED APPROACH TO HANDLING NOISE IN MEASURING SYSTEMS
Peter K. Stein *In* AGARD Flight Test Instrumentation Sep 1972 11 p refs (For availability see N73-10450 01-14)

A small portion of the new unified approach to the engineering of measuring systems is presented. The presentation and examples are selected to show the application of this approach to the determination, suppression, and documentation of noise levels in flight test measuring systems in which the initial measuring is of analog nature. A systematic methodology is developed for the determination and documentation of noise levels on any given test set-up, at any time, before, during or after a test, and without specific knowledge of the environmental factors which cause these noise levels. A strong plea is made for the recognition of measurement systems engineering as a discipline in its own right, which can and must be incorporated into engineering curricula. The unified approach is offered as a starting point towards this end. The need for additional concept-research in this field is identified and the hope is expressed that united efforts among various nations will result in the production of measurement-oriented or measurement-conscious engineers of all disciplines and at all levels. Author

N73-10457 Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany)
IMPACT OF NEW TECHNOLOGY AS ILLUSTRATED IN AN ADVANCED OPERATIONAL DATA SYSTEM
Josef Herrmann *In* AGARD Flight Test Instrumentation Sep 1972 11 p (For availability see N73-10450 01-14)

The impact of new technology in flight test instrumentation equipment is given for a comprehensive and advanced airborne data acquisition system and ground data processing station. This advanced operational data system is used for flight testing of the high performance MRCA aircraft involving several aircraft prototypes for different tasks at different test sites. Author

N73-11407# Advisory Group for Aerospace Research and Development, Paris (France)
V/STOL DISPLAYS FOR APPROACH AND LANDING
Jul 1972 50 p refs
(AGARD-R-594) Avail NTIS HC $4.50

The design and development of display systems were studied for developing all weather operational capability in terminal areas for V/STOL aircraft. Aspects of the study discussed include operational factors and ground environment, vehicle configuration, terminal area flight profiles, pilot factors, tradeoffs, guidance and control, and human engineering. The conclusions of the study are summarized, and the recommendations for future research and development are included. F.O.S.

N73-18439# Advisory Group for Aerospace Research and Development, Paris (France)
DISPLAYS FOR APPROACH AND LANDING OF V/STOL AIRCRAFT
Nov 1972 17 p
(AGARD-AR-51) Avail NTIS HC $3.00 CSCL 01B

An analysis of the display systems required for approach and landing of V/STOL aircraft was conducted. The various factors considered in the analysis are (1) operational factors and ground environment, (2) guidance requirements, (3) relation between control and display sophistication, (4) information requirements, (5) human factors engineering, and (6) current display devices. Diagrams of proposed instrument panels and display devices are included. Author

N73-20499# Advisory Group for Aerospace Research and Development, Paris (France)
AGARD FLIGHT TEST INSTRUMENTATION SERIES. VOLUME 2: IN-FLIGHT TEMPERATURE MEASUREMENTS
F. Trenkle, M. Reinhardt, W. D. Mace, ed., and A. Pool, ed.
Feb 1973 171 p refs
(AGARD-AG-160-Vol-2; AGARDograph 160 Vol 2) Avail NTIS HC $10.75

The field of temperature measurements in aircraft at Mach numbers up to 2.3 and altitudes up to 80,000 feet is reported. After a general discussion of the requirements of aircraft temperature measurements, and the available temperature sensing technology, the detailed techniques of using resistance probes and thermocouples, as well as the associated electrical leads, circuits, and indicators are explained. A discussion of heat transfer processes, primarily between moving fluids and solids, includes terminology, the systematics of temperature measurements, and the concept of total temperature as the main operational parameter. One section deals with errors in temperature measurements, as functions of various parameters, in gases, liquids and solids. Typical laboratory and in-flight calibration techniques for thermometery are described, followed by discussions of data handling, error analysis, and the limits of present methods.
Author

N74-14116# Advisory Group for Aerospace Research and Development, Paris (France)
AGARD FLIGHT TEST INSTRUMENTATION SERIES. VOLUME 4: THE MEASUREMENT OF ENGINE ROTATION SPEED
M. Vedrunes, W. D. Mace, ed., and A. Pool, ed. Oct 1973 32 p refs 4 Vol
(AGARD-AG-160-Vol-4) Avail NTIS HC $3.75

The techniques and systems used to measure engine rotation speeds are analyzed. Chronotachometers, tachogenerators, and magnetic sensors are discussed along with the design of airborne measuring systems. The advantages and disadvantages of each type are presented. The telemetry systems and calibration procedures are described. For Vol. 2 see N73-20499; for Vol. 3 see N72-25420. F.O.S.

15 MACHINE ELEMENTS AND PROCESSES

Includes bearings, seals, pumps and other mechanical equipment, lubrication, friction, and wear, manufacturing processes and quality control, reliability, drafting, and materials fabrication, handling, and inspection

N72-19541# Advisory Group for Aerospace Research and Development, Paris (France) Structures and Materials Panel
APPLICATION OF NON-DESTRUCTIVE INSPECTION METHODS TO AIRCRAFT STRUCTURES
P Gallinaro and R B Oliver Oct 1971 34 p refs
(AGARD-R-587-71) Avail NTIS

Nondestructive test methods are defined and their application for inspection of aircraft structures is evaluated, based on the results of an aircraft industry survey. For individual titles, see N72-19542 through N72-19543

N72-19542# Advisory Group for Aerospace Research and Development, Paris (France)
NONDESTRUCTIVE INSPECTION OF STRUCTURES
P Gallinaro *In its* Appl of Nondestructive Inspection Methods to Aircraft Struct Oct 1971 p 3-14 refs (See N72-19541 10-15)
Avail NTIS

Current methods of inspection are reviewed and their application is defined for three major areas (1) inspection of adhesive bonded structures (2) inspection of welded joints and (3) inspection of riveted or bolted joints D L G

N72-19543# Advisory Group for Aerospace Research and Development, Paris (France)
SURVEY ON THE APPLICATION OF NONDESTRUCTIVE INSPECTION METHODS TO COMMERCIAL AIRCRAFT, 1968 TO 1970
Robert B Oliver *In its* Appl on Nondestructive Inspection Methods to Aircraft Struct Oct 1971 p 15-20 (See N72-19541 10-15)
Avail NTIS

Data related to the application of nondestructive inspection methods were acquired from commercial airline overhaul bases, airframe manufacturers, research laboratories and equipment manufacturers. The project was aimed at (1) evaluating the current experiences in nondestructive inspection, (2) isolating the best nondestructive inspection procedures, and (3) making recommendations to improve the accuracy of the methods and to stimulate development of improved methods. The results of the project are presented in the form of a state-of-the-art review D L G

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16 MASERS

Includes applications of masers and lasers. For basic research see 26 Physics, Solid-State

N72-25493# Advisory Group for Aerospace Research and Development, Paris (France)
LASER TECHNOLOGY IN AERODYNAMIC MEASUREMENTS AGARD Lecture Series
R C Pankhurst, ed Mar 1972 249 p refs Presented at Rhode-Saint-Genese, Belgium, 14-18 Jun 1971 sponsored by AGARD Fluid Dyn Panel and von Karman Inst for Fluid Dyn
(AGARD-LS-49) Avail NTIS HC $14.50

The proceedings of a conference on the use of lasers for measuring aerodynamic applications are presented The subjects discussed are (1) principles of holography, (2) mathematical methods in coherent optical systems analysis, (3) laser beams for aerodynamic flow field analysis, (4) laser Doppler velocimeters for wind tunnel applications, (5) laser applications for high speed photography, and (6) laser metrology For individual titles, see N72-25494 through N72-25506

N72-25494# Tennessee Univ, Tullahoma Space Inst
AN INTRODUCTION TO THE LASER
T H Gee *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 5 p refs (See N72-25493 16-16)
Avail NTIS HC $14.50

The basic principles of laser operation are discussed The properties which characterize its performance as a source of quasi-monochromatic radiation in and near the visible range of the electromagnetic spectrum are described The various materials which are used for lasers and the construction of the resonant cavity are explained The three classes of energy levels are discussed and schematic representations are included Author

N72-25495# Tennessee Univ, Tullahoma Space Inst
PRINCIPLES OF HOLOGRAPHY
T H Gee *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 13 p ref (See N72-25493 16-16)
Avail NTIS HC $14.50

The principles of holography are discussed Holography is the process of recording complex wavefronts of light scattered by a scene (object) and subsequent release of the recorded wavefronts to reconstruct the original scene The reconstruction contains all of the geometrical characteristics of the original scene which one would observe by viewing the scene through a window whose dimensions are those of the recording medium The basis of the recording process is interferometry A complex wavefront is made to interfere with a known reference wave and the result recorded by a square law detector Author

N72-25496# Tennessee Univ Tullahoma Space Inst
MATHEMATICAL METHODS IN COHERENT OPTICAL SYSTEMS ANALYSIS. FIRST ORDER ANALYSIS OF A HOLOGRAPHIC SCHLIEREN SYSTEM
T H Gee *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 7 p refs (See N72-25493 16-16)
Avail NTIS HC $14.50

The mathematical methods employed in the analysis of coherent optical systems are demonstrated by an illustrative example This example involves an optical configuration which may be employed as a holographic Schlieren system and illustrates the Fourier transform properties of positive thin lens hologram formation and reconstruction magnification and various approximations which are normally made in a first order analysis The coherent optical configuration is presented Author

N72-25497# Queen Univ Belfast (Northern Ireland)
EFFECTS OF COHERENCE ON FLOW VISUALIZATION METHODS
L H Tanner *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 2 p (See N72-25493 16-16)
Avail NTIS HC $14.50

The application of coherent light to flow visualization procedures is discussed Diagrams illustrating the differences between thermal light sources and coherent light sources are presented The advantages of laser light over conventional light are described and mathematical models are included to support the theoretical considerations Author

N72-25498# ARO, Inc, Arnold Air Force Station, Tenn
AERODYNAMIC HOLOGRAPHY
J D Trolinger *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 18 p refs (See N72-25493 16-16)
Avail NTIS HC $14.50

Applications of holography in aerodynamics and related mechanics are discussed Included are holographic generalized flow visualization, interferometry, and three dimensional recording The high resolution analysis of dynamic nearly transparent three dimensional field of light scattering elements is described Specific applications of particulate matter in explosions, plasmas, rocket and engine exhausts, and in wind tunnel and similar research facilities are examined It is concluded that holography provides data not obtainable by other means and has economic and technical advantages over conventional means of data acquisition Author

N72-25499# Michigan Univ, Ann Arbor Inst of Science and Technology
EXPERIMENTAL HOLOGRAPHY
J Upatnieks *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 8 p refs (See N72-25493 16-16)
Avail NTIS HC $14.50

The formation of a hologram and the recording of the interference pattern between a reference beam and the light waves reflected from an object or scene are discussed Holography is interferometry and the technology of this subject applies to holography as well The factors affecting the formation of the hologram, the quality and characteristics of reconstructed images, and various optical systems for constructing holograms are considered Author

N72-25500# Michigan Univ, Ann Arbor Radar and Optics Lab
CHARACTERISTICS OF DIELECTRIC HOLOGRAMS
J Upatnieks and C D Leonard *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 9 p refs (See N72-25493 16-16)
(Contracts F33615-67-C-1814, F33615-68-C-1310)
Avail NTIS HC $14.50

The diffraction efficiency and signal-to-noise ratio for two-dimensional and volume diffuse-signal-beam holograms are calculated and experimentally determined Calculations are based on the statistical properties of the signal beam, and exact integrals rather than series approximations are used High signal-to-noise ratio and high diffraction efficiency are possible, with the peak calculated diffraction efficiency being 22% for two-dimensional and 64% for volume holograms The experimentally achieved efficiencies were 12% for two-dimensional and 36% for volume holograms Author

N72-25501*# TRW Systems Group, Redondo Beach, Calif
PULSED LASER HOLOGRAPHY
R F Wuerker and L O Heflinger *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 14 p refs Previously published in The Eng Uses of Holography by E R Robertson and J M Harvey Cambridge Univ Press 1970 (See N72-25493 16-16)
(Contracts NASw-1572, JPL-952023, F04611-67-C-0105, F33615-68-C1119)
(NASA-CR-128767) Avail NTIS HC $3.00 CSCL 20E

The development of optical systems used in holography which compensate for the limited spatial temporal coherence of Q-switched ruby laser illuminators is discussed. The employment of the equipment to record projectiles in flight, aerodynamic wakes, and electric discharge plasmas is described. Diagrams and drawings are supplied to show the construction and operation of the system. P N F

N72-25502# TRW Systems Group, Redondo Beach, Calif
RUBY LASER HOLOGRAPHY
R F Wuerker and L O Heflinger *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 13 p refs Repr from SPIE J, v 9, 1971 p 122-130 also from Proc of the Conf in Anaheim Calif, 14-17 Sep 1971 (See N72-25493 16-16)
(Contract F33615-69-C-1630)
Avail NTIS HC $14.50

The solid state ruby laser for recording of holograms without either the granite tables or vibration isolation equipment needed with gas lasers is discussed. The ruby laser is unique in that it can be made to emit several joules of light in a tenth of a microsecond. In their more conventional form, these lasers are not particularly coherent, due to the width of the ruby R sub 1 lasing transition. Temporal coherence can be as low as one centimeter. The development of holographic configurations which compensated for the limited spatial and temporal coherence of ruby lasers is considered. These were used to record transmission holograms of combustion in rocket engines, aerodynamic flow patterns, and particulate matter in coal furnaces. Author

N72-25503# Institut Franco Allemand de Recherches, St Louis (France)
LASER BEAM PROBING FOR AERODYNAMIC FLOW FIELD ANALYSIS
Bernard Koch *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 20 p refs (See N72-25493 16-16)
Avail NTIS HC $14.50

The application of laser beams for the measurement of aerodynamic flow fields at supersonic and hypersonic speeds is discussed. The subjects presented are (1) basic methods of optoelectronic flow field probing, (2) single beam techniques, (3) small diameter beam method for supersonic free jet investigation, (4) twin or multiple beam techniques, (5) crossing beam method, (6) multiple beam interferometry, and (7) Doppler difference method. Author

N72-25504# Max-Planck-Institut fuer Plasmaphysik, Munich (West Germany)
LASER: A LIGHT SOURCE FOR HIGH SPEED PHOTOGRAPHY
K Buechl *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 22 p refs (See N72-25493 16-16)
Avail NTIS HC $14.50

The application of lasers as an indirect light source for high speed photography is discussed. Examples of such applications are laser produced plasmas for vacuum ultraviolet light sources or electron sources, ultrafast trigger and calibration of image converter cameras, and a light gated Kerr cell. The characteristics of lasers for photographic use are described and mathematical models are included to support the theoretical considerations. Author

N72-25505# ARO, Inc, Arnold Air Force Station, Tenn Experimental Research
LASER METROLOGY
A E Lennert, D B Brayton, F L Crosswy, W H Goethert and H T Kalb *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 98 p refs (See N72-25493 16-16)
Avail NTIS HC $14.50

The development of a laser Doppler velocity instrument to measure velocities of flowing fluids is discussed. The electro-optical instruments are being developed for enhancing the measuring capabilities in wind tunnels. The basic design parameters of the input aligned optics LDV system and in particular, the development of a self-aligning system to circumvate the basic problems inherent with previously conceived systems, are described. The design and the progress made on a direct readout system to determine three orthogonal components of velocity directly are presented. A number of significant proof-of-principle experiments covering a wide variety of flows, both liquid and gaseous, are discussed. The results of a number of wind tunnel calibrations verifying the superior performance of the LDV for not only velocity determination but also to perform boundary layer measurements are also included. Author

N72-25506# ARO, Inc, Arnold Air Force Station, Tenn Experimental Research
APPLICATION OF DUAL SCATTER LASER DOPPLER VELOCIMETERS FOR WIND TUNNEL MEASUREMENTS
A E Lennert, F H Smith, and R L Parker *In* AGARD Laser Technol in Aerodyn Meas Mar 1972 16 p refs (See N72-25493 16-16)
Avail NTIS HC $14.50

A duel scatter laser Doppler velocimeter (LDV), used in both forward and back scatter modes, and a direct data readout system are described. The characteristics of the dual scatter system are such that no seeding of flow is required to effect the measurements. With minor modifications and improvements the dual scatter LVD system, both forward and back scatter, supplants conventional measuring devices. Descriptions of the application of the instrument to actual wind tunnel measurements including calibration of a one-foot transonic wind tunnel, flow field measurements of a simulated helicopter downwash, and flow field mapping across a high lift wing section are included. Author

17 MATERIALS, METALLIC

Includes cermets corrosion, physical and mechanical properties of materials, metallurgy, and applications as structural materials. For basic research see 06 Chemistry. For related information see also 18 Materials, Nonmetallic and 32 Structural Mechanics.

N72-20491# Advisory Group for Aerospace Research and Development, Paris (France)
NATO NATIONAL REPORTS ON HIGH TEMPERATURE CORROSION OF AEROSPACE ALLOYS
R. I. Jaffee, ed. (Battelle Mem. Inst., Columbus, Ohio) Feb. 1972 36 p
(AGARD-R-591) Avail: NTIS

A presentation, in a series of brief statements, on much of the research and development work in progress and some that is planned, in nine (9) NATO countries, on high temperature corrosion of aerospace alloys is given. Author

N73-23597# Advisory Group for Aerospace Research and Development, Paris (France)
HIGH TEMPERATURE CORROSION OF AEROSPACE ALLOYS
J. Stringer, ed. (Liverpool Univ.), R. I. Jaffee, ed. (Battelle Columbus Labs., Ohio), and T. F. Kearns, ed. (Naval Air Systems Command) Mar. 1973 338 p refs In ENGLISH and partly in FRENCH Conf. held at Lyngby, Denmark, 10-12 Apr. 1972
(AGARD-CP-120) Avail: NTIS HC $19.00

Results are presented of conference discussions on the effects of high temperature corrosion and oxidation of alloys for future applications in aerospace vehicles. For individual titles, see N73-23598 through N73-23618

N73-23598 Max-Planck-Institut fuer Physikalische Chemie, Goettingen (West Germany)
GENERAL ASPECTS OF HIGH TEMPERATURE CORROSION OF STRUCTURAL MATERIALS
Carl Wagner *In* AGARD High Temp. Corrosion of Aerospace Alloys Mar. 1973 p 3-7 refs (For availability see N73-23597 14-17)

An oxidation scale for high temperature corrosion of structural materials is examined and its requirements established. Scale requirements include (1) low concentration of ionic defects effective in metal ion transport, (2) negligible vaporization of oxides in the scale, and (3) freedom from pores or cracks and firm adherence to underlying alloy even during rapid temperature changes. Author

N73-23599 National Gas Turbine Establishment, Pyestock (England)
THE ENVIRONMENT ENCOUNTERED BY HIGH TEMPERATURE COMPONENTS OF THE AIRCRAFT GAS TURBINE
J. E. Restall *In* AGARD High Temp. Corrosion of Aerospace Alloys Mar. 1973 p 11-30 refs (For availability see N73-23597 14-17)

A brief examination is made of the factors governing the behavior of hot components, combustion chamber, nozzle guide vanes and turbine rotor blades, in aero engines in the absence of a hot salt corrosion environment. The effects on components in engine trails of controlled additions of salt made to the intake air and fuel are discussed. Author

N73-23600 Societe Nationale d'Etudes et de Construction de Moteurs Aeronautiques, Corbeil (France)
MATERIALS CURRENTLY EMPLOYED IN HIGH TEMPERATURE COMPONENTS OF THE AIRCRAFT GAS TURBINE
M. Bruneraud *In* AGARD High Temp. Corrosion of Aerospace Alloys Mar. 1973 p 31-42 In FRENCH; ENGLISH summary (For availability see N73-23597 14-17)

General aspects of the high temperature components of the gas turbine are briefly reviewed, along with mechanical and chemical properties required of materials. Commercial nickel and cobalt base superalloys are reviewed in terms of their 1000-hour rupture strengths, together with some experimental alloys currently being developed. This last group includes powder metallurgy alloys, directionally solidified alloys, and alloys based on the refractory metals. Hot corrosion resistant superalloys contain high chromium contents, at the expense of high temperature strength. Designers are currently attempting to develop an intermediate group of high strength alloys with acceptable corrosion resistance complemented by aluminum-based diffusion coatings. Author

N73-23601* National Aeronautics and Space Administration, Washington, D.C.
THE ENVIRONMENT AND MATERIALS FOR GLIDE REENTRY VEHICLES
G. C. Deutsch *In* AGARD High Temp. Corrosion of Aerospace Alloys Mar. 1973 p 43-59 (For availability see N73-23597 14-17)
CSCL 22C

The environmental conditions to which a large glide reentry vehicle such as the space shuttle is subjected is discussed. A comparison is made with the state of the art for materials and structures to meet this environmental threat. The options that are available are stressed as are the areas where additional research and development is required. Author

N73-23602 Belgian Center for Corrosion Study, Brussels
WHAT ARE THE ADVANTAGES AND LIMITATIONS IN THE USE OF EQUILIBRIUM THERMODYNAMICS FOR THE TREATMENT OF COMPLEX HIGH TEMPERATURE CORROSION REACTIONS?
M. Pourbaix *In* AGARD High Temp. Corrosion of Aerospace Alloys Mar. 1973 p 63-78 refs (For availability see N73-23597 14-17)

The conditions of thermodynamic stability of every species which may exist in a given system, whatever the complexity, may be represented by means of suitable diagrams. These enable one to predict the general conditions (temperature, pressure, composition of the gaseous phase) where a given solid or liquid compound may be stable, metastable or unstable. Three types of diagram are illustrated in which the ordinates and abscissae are respectively log P sub O2 and 1/T, RT ln P sub O2 and T, and E and T. The relative values of these methods of representation are discussed and their applications to the studies of corrosion problems is outlined. Author

N73-23603 Orleans Univ. (France)
RELATIONS BETWEEN INITIAL METALLIC SUBSTRATE, AND FIRST STAGE OF THE REACTION AND FORMATION OF OXIDE LAYERS [RELATIONS ENTRE L'ETAT INITIAL D'UN SUBSTRAT METALLIQUE, LES PREMIERES ETAPES DE LA REACTION ET LA FORMATION DES COUCHES D'OXYDE]
J. Bardolle *In* AGARD High Temp. Corrosion of Aerospace Alloys Mar. 1973 p 79-95 refs In FRENCH; ENGLISH summary (For availability see N73-23597 14-17)

The influence of surface preparation on the state of crystallization near the metal surface is summarized, and it is noted that the damaged layer introduced by mechanical polishing can be removed by electropolishing. Several examples are quoted on the effect of surface preparation on the growth of thin oxide films. Minor impurities in the metal or at the oxidizing surface may have a marked effect on the oxidation rate, and in particular on the scale, metal adhesion, impurities may also change the ductility of the oxide. The mechanisms of the early stages of an oxidation reaction are briefly summarized and ways in which the progress of these may affect the later oxidation are discussed. Author

N73-23604 Central Inst. for Industrial Research, Oslo (Norway)
TRANSPORT PROCESSES IN SCALES IN HIGH TEMPERATURE CORROSION

P Kofstad *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 97-116 refs (For availability see N73-23597 14-17)

Scales are characterized as (1) porous, (2) dense and compact, or (3) continuous, but containing appreciable porosity or voids. Porous scales are not normally associated with protective oxidation behavior, and are not discussed, dense and compact scales are very uncommon in practice, but can usefully be discussed as a limiting ideal case. The kinetics of the growth of a scale in which the rate limiting process is the transport of reactants and electrons through the scale is very briefly summarized. The transport properties of a number of oxides are reviewed to determine which is the most desirable scale to be formed on an oxidation-resistant alloy. Although it is clear that the formation of a Cr2O3 layer will result in a reduction in the oxidation rate of Ni and Co, there is no doubt that the most protective scale layer would be Al2O3, and this is consistent with observation. There are many possible effects of impurities on diffusion rates in oxides, and the example of lower valent cations dissolving in an oxygen deficient M O2 oxide is briefly discussed. The influence of porosity on the growth of a substantially compact scale is discussed, and it was concluded that on balance it is undesirable, often enhancing the oxidation rate and weakening the scale. Selective and internal oxidation are clearly of great importance, and the latter is associated with the solution of oxygen in the metal. The effects of the mechanism of oxygen diffusion, of pretreatment and microstructure of alloys, and of alloy composition are discussed. Some aspects of reactions involving sulphur are also reviewed. Author

N73-23605 Cranfield Inst of Technology (England)

WHAT IS THE ROLE OF STRESS IN OXIDATION, INCLUDING BOTH EXTERNALLY-APPLIED AND GROWTH STRESSES? WHAT ARE THE MODES OF STRESS-RELAXATION? HOW DOES THERMAL CYCLING AFFECT THE STRESSES AND STRESS RELAXATION?

P Hancock *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 117-128 refs (For availability see N73-23597 14-17)

The isothermal stresses generated during oxidation can be attributed to four main causes (1) the volume ratio between the metal and the oxide formed (2) the epitaxial relationship between the oxide and the metal, (3) composition changes in either the metal or the oxide, and (4) the influence of vacancies generated during oxidation. In any single oxidation process all of these factors may contribute, but the influence of component geometry on these processes is often critical and invariably neglected. Mechanisms of stress relief include cracking of the oxide film, plastic deformation of the scale, and in some circumstances deformation of the underlying metal. The mechanisms of plastic deformation of the scales are reviewed and the effects of thermal stresses considered. Author

N73-23606 Yale Univ, New Haven, Conn Dept of Engineering and Applied Science

ENVIRONMENTAL EFFECTS ON GAS/METAL REACTIONS AT ELEVATED TEMPERATURES

D E Rosner *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 129-144 refs (For availability see N73-23597 14-17)

To anticipate the effects of unusually severe operating conditions, or to design readily interpretable oxidation kinetic experiments, consideration is given to the conditions of convection, diffusion, and chemical change in the immediate vicinity of the gas/solid interface. Recently exploited methods are outlined for accomplishing this by combining simple conservation principles with computational techniques and experimental data developed by chemical, mechanical, and aeronautical engineers for dealing with similar physical situations. Important effects on gas/solid oxidation rates associated with gas flow rate, enthalpy, pressure level, and/or chemical composition (especially dissociation) are discussed, both from the points of view of making reliable rate predictions based on available chemical and physical data, and designing kinetic experiments from which fundamental information can be extracted. Author

N73-23607 Ohio State Univ, Columbus

VAPORIZATION LOSSES FROM Cr2O3 PROTECTIVE SCALES

R A Rapp *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 147-154 refs (For availability see N73-23597 14-17)

Vaporization thermodynamics and kinetics are reviewed. The vaporization of Cr2O3 scales occurs with the formation of CrO3 and Cr(OH)2 vapor species. The maximum possible rate of vaporization is given by the Hertz-Langmuir equation, but in the practical case the rate is limited by mass transport through a stagnant boundary layer, the thickness of which depends on the local gas velocity. In turbulent near-sonic flow the vaporization rate may therefore approach the theoretical maximum. It is suggested that the only possibility for the use of protective Cr2O3 scales in reactive high-velocity atmospheres is to separate the Cr2O3 scale from the environment by a compact and stable surface oxide which is low in the activity of Cr2O3. However, external spinel scales are generally spalled through thermal shock. There is considerable evidence to suggest that the formation of a protective alpha-Al2O3 scale effectively inhibits the evaporative loss of chromium from an alloy. Author

N73-23608 Pratt and Whitney Aircraft, East Hartford, Conn

ON THE EFFECTS OF OXIDE DISPERSIONS AND RARE-EARTH TYPE ELEMENTS ON THE OXIDATION OF Cr AND Al-CONTAINING ALLOYS

F S Pettit *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 155-172 refs (For availability see N73-23597 14-17)

The effects of oxide dispersions and rare-earth type elements on the oxidation of alloys upon which Cr2O3 or Al2O3 scales are formed is discussed. It is shown that oxide dispersions and rare-earth type elements can both apparently affect the adherence, growth rate, and growth mechanism of Cr2O3 as well as the selective oxidation of chromium in alloys. In the case of alloys upon which Al2O3 scales are formed, however, oxide dispersions and rare-earth elements appear to affect only the adherence of the scale. The differences between effects produced by oxide dispersions and rare-earth type elements is examined. Author

N73-23609 Liverpool Univ (England)

THE APPLICATION OF MULTICOMPONENT DIFFUSION THEORY TO THE OXIDATION AND CORROSION OF COMPLEX SUPERALLOYS

D P Whittle *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 173-200 refs (For availability see N73-23597 14-17)

The relevant phenomenological equations for multicomponent diffusion and methods of obtaining their solution are briefly presented. Possible forms which the calculated diffusion paths may adopt are indicated and the relevance of these to the oxidation and sulfation of alloys is discussed. The multicomponent diffusion equation was solved for transport in the alloy when one of the alloy components was being selectively removed by oxidation or sulfation. Two cases are considered where the oxidant is insoluble in the alloy when the composition of the alloy/scale interface is important in determining which phase is stable in the scale, and when the oxidant is soluble and can diffuse into the alloy, possibly producing internal precipitation of sulphide or oxide. The relevant conditions for internal precipitation are also presented. In both cases, the importance of diffusional interaction is stressed. Author

N73-23610 Admiralty Materials Lab, Poole (England)

WHAT ARE THE SEPARATE AND INTERACTING ROLES OF SULPHUR, SODIUM AND CHLORIDE IN HOT CORROSION?

J F G Conde *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 203-220 refs (For availability see N73-23597 14-17)

The origins of the sulfur, sodium and chloride contaminants are discussed and the conditions existing in the gas turbine are examined. The chemistry of contaminants in the combustion environment is introduced and evidence is cited to show that in the short residence times available, gas phase sulfation of chloride

is not significant The mechanism of salt deposition in the gas turbine on nozzles and blades is considered briefly and the role of the obvious contaminants sulfur, sodium and chloride is examined in relation to sulfidation and accelerated oxidation A model is suggested in which periodically extremely local non-equilibrium conditions arise on the surface of nozzles and turbine blades due to impaction of sea-salt particles It is suggested that such conditions may permit chloride to destroy the integrity of protective scale layers under low oxygen pressure conditions existing beneath liquid sulfate deposits Author

N73-23611 Centre National de Recherches Metallurgiques, Liege (Belgium)
WHAT ARE THE EFFECTS OF ALLOYING ELEMENTS SINGLY OR IN COMBINATION ON HOT CORROSION?
A Davin and D Coutsouradis *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 221-233 refs (For availability see N73-23597 14-17)

As single additions only chromium or aluminium are reported to improve the oxidation resistance of nickel and cobalt appreciably, due to their forming protective scales of Cr_2O_3 and Al_2O_3 respectively at sufficiently high concentrations When the two elements are added together, the presence of the chromium causes a stable layer of Al_2O_3 to develop at lower aluminum concentrations than in the binary systems, due to the gettering effect of the chromium in the metal which impedes the inward diffusion of oxygen and prevents internal oxidation of the aluminum Author

N73-23612 Naval Ship Research and Development Center, Annapolis, Md
ARE COBALT-BASE ALLOYS INTRINSICALLY MORE RESISTANT TO HOT CORROSION THAN ALLOYS BASED ON NICKEL?
W L Wheatfall *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 235-254 refs (For availability see N73-23597 14-17)

A literature search was made in an effort to determine if cobalt-base alloys are intrinsically better than alloys based on nickel relative to hot-corrosion resistance Results of the search did not confirm whether cobalt alloys were inherently more resistant than nickel alloys Failure to resolve this controversy was due mainly to two factors (1) insufficient hot-corrosion data comparing pure nickel and cobalt, and (2) contradictions with regard to the roles of sulfur and the liquid sulfide phase in the hot-corrosion process A discussion and comparison of results of a number of investigations are provided along with the listing of several questions which may serve as the basis for future research efforts to finally resolve whether or not cobalt-base alloys are intrinsically more hot-corrosion resistant than alloys based on nickel Author

N73-23613 International Nickel Co Ltd, Birmingham (England)
CAN FUEL ASH CORROSION BY VANADIUM BE COMBATTED BY ALLOYING OR COATING WITHOUT THE USE OF FUEL ADDITIVES?
K J Williams and P J Parry *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 255-266 refs (For availability see N73-23597 14-17)

Materials for nozzle guide vanes and turbine blades subject to attack by the products of combustion of vanadium-containing fuels are investigated Previous operating experience of industrial gas turbines burning residual fuel is referred to, and current ASTM fuel specifications are considered Relevant developments with alloys and coatings are reviewed Recently announced alloys containing 35% - 50% chromium offer promising corrosion resistance, and an indication of the strength attainable in the 50% Cr base is given High-chromium coatings applied by pack-chromising have performed well in recent burner rig tests There is a need for more comprehensive testing of these new materials under realistic conditions, and over a range of vanadium contents Author

N73-23614 Nancy Univ (France)
WHAT ARE THE PROSPECTS FOR THE SUCCESSFUL APPLICATION OF COATED REFRACTORY METALS IN UNCOOLED TURBINES? [QUEL EST L'AVENIR DES ALLIAGES REFRACTAIRES PROTEGES DANS LA CONSTRUCTION DES TURBOMACHINES?]
B Roques *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 269-282 refs In FRENCH, ENGLISH summary (For availability see N73-23597 14-17)

Various protective coatings are investigated to determine the most effective application for refractory metal alloys used in the structural makeup of turbine engines The results indicated that coatings based on SiO_2 and Al_2O_3 constitute foundations from which improved protective oxides may be developed J M M

N73-23615 Liverpool Univ (England)
ARE THERE NEW APPROACHES TO ALLOYING WHICH MAY PRODUCE OXIDATION-RESISTANT REFRACTORY METAL ALLOYS?
J Stringer *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 283-294 refs (For availability see N73-23597 14-17)

The oxidation mechanisms of Nb, Ta, Mo and W are briefly reviewed Nb and Ta form non-protective porous scales of the pentoxides, and at the same time oxygen dissolves in the metal producing severe embrittlement It was found that at elevated temperatures, both Mo and W form volatile oxides, and reduction in the oxidation rate requires the stabilization of a foreign oxide or the development of a protective noble metal-rich layer at the surface Some molybdates and tungstates appear to have promising properties, and chromium-rich alloys forming Cr_2O_3 layers also represent significant improvements Unfortunately, all alloys so far developed which have significantly improved oxidation resistance are also very brittle Author

N73-23616 Aerospace Research Labs, Wright-Patterson AFB, Ohio
PROSPECTS FOR OXIDATION RESISTANT REFRACTORY COMPOUNDS
Norman M Tallan *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 295-309 refs (For availability see N73-23597 14-17)

Recent results of static and dynamic oxidation studies of materials which combine optimum resistance to corrosion, thermal shock fracture, fatigue, etc are presented Particular attention is directed to the potential of such materials as ZrB_2, HfB_2, SiC, Si_3N_4 and their combinations in a range of technologically important applications, including gas turbines, hypersonic and re-entry vehicles Relation of the details of the oxidation processes, their dependence on fabrication variables, and their effect on material performance are emphasized The possible use of these and related high temperature materials as coatings for refractory metals and alloys is discussed Author

N73-23617 Battelle Columbus Labs, Ohio
CONCLUDING DISCUSSION
R I Jaffee and T F Kearns (Naval Air Systems Command) *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 313-314 (For availability see N73-23597 14-17)

Reaction kinetics relative to corrosion and oxidation resistance in refractory metal alloys are discussed Emphasis is placed on the application of these alloys in the elevated temperature environments of gas turbine engines The areas dealt with include scale lattice defects evaporation, diffusion hot corrosion reaction protective coatings scale behavior in thermal shock applied stresses in oxidation effects of composition variables on scale plasticity, and testing procedures J M M

N73-23618 Battelle Columbus Labs Ohio
ANNEX B NATO NATIONAL REPORTS ON HIGH TEMPERATURE CORROSION OF AEROSPACE ALLOYS A TOPICAL LISTING OF THE RESEARCH PROGRAMS
Ian G Wright *In* AGARD High Temp Corrosion of Aerospace Alloys Mar 1973 p 321-350 (For availability see N73-23597 14-17)

The data presented in this compilation represent much of the current research and development work in NATO countries on high temperature corrosion of aerospace alloys Author

N74-23108# Advisory Group for Aerospace Research and Development, Paris (France)

METALLURGICAL ASPECTS OF FATIGUE AND FRACTURE

(AGARD-R-610) Avail NTIS HC $7.75

The proceedings of a conference to investigate the fatigue and fracture behavior of aerospace structural alloys are presented. The effect of heat treatment to prevent stress corrosion was analyzed to determine possible changes in the mechanical properties of the materials. The subjects discussed include the following: (1) metallurgical aspects of fatigue and fracture toughness, (2) developments in fatigue and fracture, (3) thermomechanical procedures to improve the properties of high strength aluminum magnesium, zinc copper alloys, and (4) the influence of microstructure on the growth of fatigue cracks. For individual titles, see N74-23109 through N74-23112

N74-23109 Royal Aircraft Establishment, Farnborough (England) Materials Dept

THE METALLURGICAL ASPECTS OF FATIGUE AND FRACTURE TOUGHNESS

P. J. E. Forsyth *In* AGARD Met Aspects of Fatigue and Fracture Toughness Dec. 1973 p 1-22 refs (For availability see N74-23108 14-17)

An analysis of the cause of fatigue cracks in materials after a period of repeated stressing is presented. The effects of crystal structure and slip plane cracks are discussed. The application of thermomechanical treatment for improved mechanical properties is described. The effects of anisotropy of micro and macro structure are reported with respect to total fatigue life and crack propagation rates. The fracture toughness of materials is analyzed to show the effects of crystal structure and metal working. Mathematical models are developed to express fracture toughness and plastic deformation Author

N74-23110 Connecticut Univ Storrs

SOME RECENT DEVELOPMENTS IN FATIGUE AND FRACTURE

A. R. Rosenfeld and A. J. McEvily (Battelle Columbus Labs.) *In* AGARD Met Aspects of Fatigue and Fracture Toughness Dec 1973 p 23-54 refs (For availability see N74-23108 14-17)

The microstructural origins of the fracture resistance of high strength steels are analyzed. Curves are presented to show schematic crack growth versus stress intensity. The mechanisms considered are fatigue cracking and stress corrosion cracking. Both phenomena exhibit three stages of crack growth as follows: (1) a threshold below which crack growth is not detected, (2) a steady state region, constant velocity for environmental attack and power law behavior for fatigue, and (3) an instability characterized by the fracture toughness for plane strain thick section behavior Author

N74-23111 Istituto Sperimentale dei Metalli Leggeri, Novara (Italy)

IMPROVEMENT OF THE PROPERTIES OF HIGH STRENGTH Al-Zn-Mg-Cu ALLOYS BY THERMOMECHANICAL PROCEDURES

E. DiRusso and S. Signoretti (Aeron Militare Italiana) *In* AGARD Met Aspects of Fatigue and Fracture Toughness Dec 1973 p 55-76 refs (For availability see N74-23108 14-17)

A thermomechanical processing technique for producing plates and forgings of 7000 series alloys (7075, 7049, 7475, 7050 etc.) showing a less transverse effect than similar conventionally processed materials was developed. This procedure, called Intermediate Thermomechanical Treatments (ITMT), is based on a combination of warm deformations and heat treatments which involve the recrystallization of the ingot in small equiaxed grains in an intermediate (or final) stage of the working. As a result of the processing, the alloys exhibit better ductility, toughness and stress corrosion properties for a given strength than conventionally processed materials, mainly in the short transverse direction. Moreover, it has been found that the contemporary application of ITMT and final (FTMT) thermomechanical treatments of T-AHA type, which, as is known, cause a super-hardening effect with an acceptable loss in ductility, may lead to decidedly new products with properties that are much superior to those of commercial traditional products Author

N74-23112 PSI-Trans Corp., El Segundo, Calif

INFLUENCE OF MICROSTRUCTURE ON THE GROWTH OF FATIGUE CRACKS

G. Sertour and C. Bathias *In* AGARD Met Aspects of Fatigue and Fracture Toughness Dec. 1973 p 77-90 refs (For availability see N74-23108 14-17)

The application of the failure mechanism concepts to the development of fatigue induced cracks is discussed. The influence of microstructure on the propagation of fatigue induced cracks is analyzed. The metallurgic parameters which play a part at the very level of crack propagation mechanisms are examined. It is stated that the most important parameter which governs the development of fatigue induced cracks is the nature of the plastic deformations which occur at the crack tip. Such deformations are essentially related to the slip character and to the stacking fault energy. The influence of structure on fatigue induced crack development is reviewed with emphasis on the formation of striations and on the environment-structure interaction on crack growth Author

18 MATERIALS, NONMETALLIC

Includes corrosion, physical and mechanical properties of materials (e.g., plastics), and elastomers, hydraulic fluids, etc. For basic research see 06 Chemistry. For related information see also 17 Materials, Metallic, 27 Propellants, and 32 Structural Mechanics.

N71-25027# Advisory Group for Aerospace Research and Development, Paris (France)

HANDBOOK OF BRITTLE MATERIAL DESIGN TECHNOLOGY

W H Dukes Feb 1971 161 p refs

(AGARD-AG-152-71, AGARDOGRAPH-152) Avail NTIS

Structural data on brittle nonmetallic refractory materials such as oxides, carbides, borides, and graphite are provided for use in designing reentry vehicles and propulsion systems. The term brittle materials is used to describe materials which show no plastic deformation under stress but deform elastically until failure. The principles and practices for achieving reliability with structures constructed with brittle materials are described in detail. Design stresses, stress analysis, mechanical properties, and design criteria are discussed. F O S

N71-27038# Advisory Group for Aerospace Research and Development, Paris (France)

THE CHARACTERIZATION AND APPLICATION OF MATERIALS

May 1971 151 p refs

(AGARD-LS-51-71) Avail NTIS

CONTENTS

N71-27039# Pennsylvania Univ, Philadelphia School of Metallurgy and Materials Science

A SYSTEMS APPROACH TO THE SELECTION AND APPLICATION OF MATERIALS

Robert Maddin *In* AGARD The Characterization and Appl of Mater May 1971 20 p refs (See N71-27038 15-18)

Avail NTIS

Analyses undertaken by a materials engineer in a material's system concept consist of market applications, shape of required parts, environmental effects on exposed part, material properties in relation to environment and selection of materials and feasible manufacturing processes. Characterization of a material includes precise descriptions of its chemical composition, impurities, and factors associated with grain and substructures. G G

N71-27040# Northwestern Univ, Evanston, Ill Technological Inst

CHARACTERIZATION, SELECTION, AND USE OF HIGH STRENGTH STEELS

W S Owen *In* AGARD The Characterization and Appl of Mater May 1971 19 p refs (See N71-27038 15-18)

Avail NTIS

The principles and ideas on which modern ultra-high strength steels have been developed are outlined and a few concepts of basic importance are illustrated by a description of specific alloys and thermal and mechanical treatments which are applied to them. Considered exclusively are those alloys intended to possess a very high strength, as defined by the yield stress or the flow stress, at a small offset (less than 0.2% strain) combined with acceptable ductility. It is assumed that components made from these steels are subjected to static loading, a slow applied strain rate or very low frequency cyclic loading at temperatures within 100 degrees of room temperature. Of primary importance is the resistance of these alloys to stress corrosion and related effects. Most of the features of the structure of importance in this context are those which can be studied by optical microscopy. Author

N71-27041# California Univ, Berkeley Lawrence Radiation Lab Inorganic Materials Research Div.

NATURE, STATUS, AND SELECTION OF CERAMIC MATERIALS

Joseph A Pask *In* AGARD The Characterization and Appl of Mater May 1971 66 p Sponsored by AEC (See N71-27038 15-18)

Avail NTIS

Ceramic materials are identified as having ionic covalent bonding, being composed of compounds, and being either crystalline or glassy. The oxides are of particular interest because of their chemical stability up to high temperatures. Brittle behavior makes them sensitive to flaws either intrinsic or extrinsic, thus requiring a uniform distribution of uniform flaws to achieve reliability. Intrinsic flaws can be correlated with character features. Extrinsic flaws in themselves are character features. Both of these features can be correlated with mechanical properties and behavior. A number of applications of ceramic materials based on their unique properties of chemical resistance, high strength/density rations, high modulus of elasticity/density ratios, hardness, optical transparency, and electrical resistance are revised. Author

N71-27042# Ecole d'Application des Hauts Polymeres, Strasbourg (France)

CHARACTERIZATION, SELECTION, AND USE OF POLYMERIC MATERIALS [PROPRIETES, SELECTION ET APPLICATIONS DES POLYMERES]

C Wippler *In* AGARD The Characterization and Appl of Mater May 1971 14 p In FRENCH, ENGLISH summary (See N71-27038 15-18)

Avail NTIS

Polymeric substances are classified as either thermosetting or thermoplastic resins. Tha first category includes phenolic resins, urea and melamin formaldehyde resins, epoxy resins, unsaturated polyesters, and elastomers. These are polymeric substances, the synthesis of which is achieved during the processing by the curing phase. The second category includes polyvinyl resins, polyethylene, polyvinyl chloride, polystyrene. Their state essentially depends on temperature and time scale. Their properties are influenced not only by their chemical nature, but also by their molecular weight and molecular structure. The selection of a polymeric substance for a

given application depends on a number of physio-chemical characteristics thermal characteristics mechanical characteristics electric or optical characteristics, and on its cost Author

N71-27043# National Physical Lab Teddington (England)
FIBRE REINFORCED MATERIALS
A Kelley *In* AGARD The Characterization and Appl of Mater May 1971 12 p (See N71-27038 15-18)
Avail NTIS

A new range of materials which are made of strong, stiff fibers embedded in a matrix which may be resin, metal, or even glass is considered Some of the properties of the new strong fibers are listed, their arrangements in a fiber-reinforced body are strikingly similar to that found in natural materials The present state of knowledge about the principles of fiber reinforcement is reported A clear distinction is made between a brittle solid which breaks sharply with little and no flow, and a fragile solid which breaks easily Cracks which usually lead to breaking behave differently in a fragile solid and in a fibrous aggregate, though both are brittle Author

N71-27044# Forgeal, Issoire (France)
NEW BASIS OF CLASSIFICATION AND SELECTION OF ALUMINUM ALLOYS [NOUVEAUX CRITERES DE CARACTERISATION ET DE SELECTION DES ALLIAGES D'ALUMINUM]
J Tigeot *In* AGARD The Characterization and Appl of Mater May 1971 28 p refs In FRENCH and ENGLISH (See N71-27038 15-18)
Avail NTIS

Aluminium alloys are the material most widely used in modern airframe construction since, even where they are designed to fly at around Mach 2 5, military aircraft do not hold these speeds long enough for the temperature increase due to airflow to affect the performance of the light alloys involved The aluminium alloys most frequently used are aluminium, copper magnesium alloys, or aluminium/zinc/magnesium/copper alloys Reviewed are attempts to improve the normal mechanical properties of alloys, refine assessment of the susceptibility of an alloy to brittle fracture, obtain greater understanding of corrosion performance and determine fatigue performance Author

N71-27045# Societe Trefimetaux Argenteuil (France)
CHARACTERIZATION, SELECTION AND USE OF TITANIUM BASE ALLOYS [CARACTERISATION, SELECTION ET UTILISATION DES ALLIAGES DE TITANE]
R Syre *In* AGARD The Characterization and Appl of Mater May 1971 46 p refs In FRENCH and ENGLISH (See N71-27038 15-18)
Avail NTIS

The advantages of titanium alloys are based primarily on their mechanical property density ratio developed by addition of alloying elements and heat treatments Alloy selection for the two major applications (airframes and jet engines) is based on stringent characterization criteria such as fracture toughness stress corrosion resistance and fatigue strength in addition to creep resistance low cycle fatigue strength and thermal stability for jet engine design Fasteners hydraulic tubings and castings provide new areas of application for titanium Engineering properties vary strongly with the alloy microstructure Author

N72-12492# Advisory Group for Aerospace Research and Development Paris (France)
COMPOSITE MATERIALS
Sep 1971 225 p refs Partly in ENGLISH partly in FRENCH Conf held at Paris 2-3 Apr 1970
(AGARD-CP-63-71, AGARD CONF Proc 63) Avail NTIS

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20 STUDY OF INTERACTION BETWEEN A BERYLLIUM FIBER AND AN ALUMINUM MATRIX J P Trottier and R Graf (Office Natl D'Etudes et de Rech Aerospatiales Paris France) 9 p refs (See N72-12507 03-17)

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N72-12493# Louvain Univ (Belgium) Inst voor Metaalkunde
MECHANICAL PROPERTIES OF EPOXY-SILICA COMPOSITE MATERIALS
P deMeester, P Dambre and A Deruyttere *In* AGARD Composite Mater Sep 1971 11 p refs (See N72-12492 03-18)
Avail NTIS

Composite materials consisting of an epoxy matrix longitudinally reinforced by oriented silica fibres have been tested for their mechanical properties. Primarily the elastic coefficients have been measured. For this purpose static and dynamic measurements have been performed. Specimen forms and test results are discussed. Other mechanical properties (U T S) are also presented and discussed in view of the application of such fibre reinforced materials as structural elements. Author

N72-12494# National Physical Lab , Teddington (England) Div of Molecular Science
THE NPL UTRASONIC TANK ITS USES IN POLYMER AND FIBRE COMPOSITE TESTING
M F Markham *In* AGARD Composite Mater Sep 1971 8 p refs (See N72-12492 03-18)
Avail NTIS

Measurement of ultrasonic attenuation on composites has been shown to be a valuable qualitative method of testing these materials for voids or similar defects. Existence of these does seriously reduce the strength and indeed the elastic constants. It is therefore highly desirable that all samples are tested in this manner before further tests are carried out. The method has been applied to two composites silica epoxy and silica phenolic sheets. Values of their elastic constants are given in the appendix. Author

N72-12495# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
MODULUS OF ELASTICITY MEASUREMENTS ON RESIN FIBER COMPOSITES [MESURES DE MODULES ELASTIQUES SUR COMPOSITE FILS-RESINE]
H Guyot and M Hediard *In* AGARD Composite Mater Sep 1971 13 p refs In FRENCH, ENGLISH summary (See N72-12492 03-18)
Avail NTIS

Test specimen have a rectangular section of 4 x 10 mm. Elastic deformations are measured under a rather low stress. Three extensometers are mounted together to measure the variations of total width, of total thickness and the deformation stress and test specimen lengths. Within one percent measurements are reproductible when made on the same test specimen of furnished materials. But there is a rather great dispersion between different specimens. Moreover test specimen stressed perpendicularly to silica yarns show a rather consequential delayed elasticity. Author

N72-12496# Centre d'Etude des Matieres Plastiques, Paris (France)
LINEAR AND NONLINEAR CHARACTERISTICS OF A UNIDIRECTIONAL EPOXY-SILICON REINFORCED COMPOSITE
J Pabiot *In* AGARD Composite Mater Sep 1971 15 p refs In FRENCH, ENGLISH summary (See N72-12492 03-18)
Avail NTIS

A method for determining independent mechanical characteristics of an epoxy silica composite material in which the reinforcement is unidirectional is presented. The material takes the form of small dimension sheets. Its characteristics must allow the quantitative response prediction to all states of stress. In the linear domain the compliance tensor and in the non linear domain a criterion of breaking strength is defined theoretically. The validity of the hypotheses and results have been confirmed by submitting the characteristics as a function of the angular position of the axes. The discussion of the results concerns chiefly the percentage of fiber, its distribution and the physical appearance of the material resulting from certain stress conditions. Author

N72-12497# Fiat S p A , Turin (Italy) Lab Ricerche e Controlli Auto Avio
ELASTIC CONSTANTS EVALUATION OF A REINFORCED PLASTIC MATERIAL
A Bracco, G Mannone and M Sattin *In* AGARD Composite Mater Sep 1971 24 p refs (See N72-12492 03-18)
Avail NTIS

A theoretical and experimental analysis has been performed to evaluate the elastic constants of a silica-epoxy composite material. From a theoretical standpoint the material under test has been considered as an homogeneous body and assumed to be isotropic in the plane orthogonal to the fibers direction. Under these assumptions one can show that five independent elastic constants are sufficient to describe the elastic properties of the composite material. The values of these constants have then been plotted versus specific weight and strain rate of the samples by the use of ad hoc suitable equipments. Author

N72-12498# Army Materials and Mechanics Research Center, Watertown, Mass Theoretical and Applied Mechanics Research Lab
ELASTIC CHARACTERIZATION OF FIBER REINFORCED COMPOSITES
J M Slepetz *In* AGARD Composite Mater Sep 1971 10 p refs (See N72-12492 03-18)
Avail NTIS

The large scatter in test data observed is consistent with previous experience in fiber reinforced materials. Such variance is usually due in part to fabrication variables, variation in constituent properties, and deficiencies in test methods. It also has been suggested that local stress concentrations, particularly in transverse normal and shear tests, affect behavior in the gross scale and account for part of the data spread. The specimens were prepared with most of the fabrication variables eliminated, yet the scatter in test results was still excessive. This suggests that conventional test methods are at fault or that wide variations in composite properties are intrinsic to this class of materials. In any case the designer's problem of predicting structural behavior or of specifying required properties of composites is considerably magnified by such uncertainties concerning material properties. Author

N72-12499# California Univ , Los Angeles
MECHANICAL BEHAVIOR OF SiO2-EPOXY COMPOSITE
F Darwish and A S Tetelman *In* AGARD Composite Mater Sep 1971 7 p refs (See N72-12492 03-18)
Avail NTIS

The effects of temperature and fiber orientation on the load carrying capacity, strength and fracture mode of SiO_2 epoxy resin composites have been investigated by means of slow bend and impact tests. Although tough and strong when loaded parallel to its fibers, the composite is shown to be weak and brittle when loaded transversely. The composite exhibited little or no notch sensitivity for notches machined along planes normal to the fibers, whereas for the case of notches machined parallel to the fibers the composite showed considerable notch sensitivity that depended on the test temperature. Increase in test temperature had the effect of reducing the load carrying capacity of both the notched and unnotched samples in both the slow bend and impact loading. Impact energy values measured for the specimens loaded parallel to their fibers showed a slight decrease with the rise in test temperature. Author

N72-12500# Army Materials and Mechanics Research Center, Watertown, Mass Theoretical and Applied Mechanics Research Lab
DETERMINATION OF MATRIX AND FILAMENT STRESS STRAIN PROPERTIES FROM TESTS MADE ON COMPOSITES
Ralph Papirno and John M Slepetz *In* AGARD Composite Mater Sep 1971 4 p refs (See N72-12492 03-18)
Avail NTIS

A simple method has been developed for the determination of the effective in situ linear and nonlinear stress strain response of the matrix and reinforcement from load-strain measurements made on composites. Two specimens with slightly different but predetermined value volume fractions of reinforcement are tested. An analysis of the load-strain data from the two specimens yields the average for the two specimens of stress-strain data for the reinforcement and for the matrix. It is shown that the method is independent of the shape of the component stress-strain curves and may be applied in the linear and nonlinear regions. General principles of specimen pair design are derived based upon a sensitivity analysis of the method which takes into account the precision of the measuring apparatus and the relative stiffnesses of the components of the composites. Author

N72-12501# Battelle Inst., Frankfurt am Main (West Germany)
DISCUSSION OF STEEL-WIRE-REINFORCED ALUMINUM ALLOYS INVESTIGATED AT BATTELLE-INSTITUT e.V., FRANKFURT AM MAIN
U Seidelmann *In* AGARD Composite Mater Sep 1971 4 p refs (See N72-12492 03-18)
Avail NTIS

Results obtained in tensile strength measurements made on steel-wire-reinforced aluminum alloys are presented. Carbon steel wire whose final strength after incorporation in the composite was about 140 plus or minus 10 kg/sq mm was coated with aluminum alloys and after hot pressing first subjected to tensile tests. With filament contents of 20 to 60 volume percent increases in strength of 200 to 350 percent were achieved, these values approaching the theoretical values. In dynamic tests on specimens reinforced with 20 volume percent the strength values measured after 2 x 10 to the seventh power load cycles were 50 percent higher than those of the unreinforced material. Author

N72-12502# Atomic Weapons Research Establishment, Foulness (England)
STRENGTHENING OF ALUMINUM BY EXPLOSIVE INCORPORATION OF BERYLLIUM WIRES
C V Jarvis and P M B Slate *In* AGARD Composite Mater Sep 1971 9 p refs (See N72-12492 03-18)
Avail NTIS

It is shown that beryllium reinforced aluminum can be prepared using an explosive bonding technique. The mechanical properties of such a composite compare well with those from samples prepared by diffusion bonding. Author

N72-12503# Groupe Pechiney, Voreppe (France) Groupe Pechiney
PRODUCTION OF ALUMINUM BERYLLIUM COMPOSITES BY HOT PRESSING [REALISATION DE COMPOSITES ALUMINUM BERYLLIUM PAR PRESSAGE A CHAUD]
R Cousserans *In* AGARD Composite Mater Sep 1971 6 p In FRENCH (See N72-12492 03-18
Avail NTIS

Hot pressing of beryllium fibers or strips into all aluminum beryllium composites by a semi-continuous method produced specimens of large dimensions depending on the pressure loads used. A combination hot pressing laminating procedure produced some difficulties because the fragility of the beryllium and the very important elastic separation between the beryllium and the aluminum alloys caused by the reduction rate necessary to obtain a good fiber matrix compounds. Transl by G G

N72-12504# Midwest Research Inst, Kansas City, Mo Center for Applied Research on Materials
MECHANISMS OF FATIGUE IN FILAMENT REINFORCED METALS
J R Hancock *In* AGARD Composite Mater Sep 1971 21 p refs Sponsored in part by AFML (See N72-12492 03-18
Avail NTIS

The mechanisms of low-cycle fatigue were studied in composites of aluminum reinforced with 34 vol % of continuous beryllium filaments. Two series of composite specimens were tested, one series fabricated using as-drawn (rough surfaces) beryllium wire and another using electropolished (smooth surfaces) beryllium wire, to determine the effects of mechanical interlock at the filament-matrix interface on fatigue performance. Axial, strain-controlled fatigue tests were performed. The cyclic stress-strain curves were identical for the two series of composite specimens while composites reinforced with as-drawn filaments exhibited longer fatigue lives than composites reinforced with electropolished filaments. This difference in fatigue lives between the two series of composites was attributed to the difference in the rate of crack growth parallel to filament-matrix interfaces. It was concluded that rough filament surfaces impede interfacial crack growth. Author

N72-12505# Rubber and Plastics Research Association of Great Britain, Shrewsbury (England)
A NEW TEST FOR THE GLASS-TO-RESIN BOND LIFE IN GRP. COMPARISON OF TYPICAL SYSTEMS EXPOSED TO WATER
M H Stone *In* AGARD Composite Mater Sep 1971 12 p refs (See N72-12492 03-18)
Avail NTIS

A new method is described for determining the life of the glass to resin bond in GRP exposed to water. The electrical conductance along the strands is measured as a function of time of exposure, and the bond life defined as the time taken for the conductance to attain a certain value. A comparison of several glass coupling agent combinations in epoxy resin exposed to boiling water showed a 7 fold range of bond life, with the S-glass HTS treatment combination giving the most durable bond. Relative bond lives at 60 and 100 C for an E glass epoxy composite gave an overall activation energy of about 30 Kcal/mole for the debonding process. Author

N72-12506# Institut de Recherches de Chimie Avancee, Paris (France)
WETTING AND TREATMENT OF REINFORCING FIBER FILAMENTS FOR ORGANIC MATERIALS [MOUILLAGE ET TRAITEMENT DES RENFORCEMENTS FILAMENTAIRES ASSOCIES A DES MATIERES ORGANIQUES]
G Mavel *In* AGARD Composite Mater Sep 1971 9 p refs In FRENCH ENGLISH summary (See N72-12492 03-18)
Avail NTIS

A technique for measuring the wetting of a monofilament by the resin itself in a temperature range permissible for the later and all along the hardening process is described. Some insight regarding the preimpregnation mechanism and some characterization of the filament rigidity is provided. Typical results are described for various reinforcements. Author

N72-12507# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
STUDY OF INTERACTION BETWEEN A BERYLLIUM FIBER AND AN ALUMINUM MATRIX [ETUDE DE L'INTERACTION ENTRE UN FIL DE BERYLLIUM ET UNE MATRICE ALUMINIUM]
J P Trottier and R Graf *In* AGARD Composite Mater Sep 1971 9 p refs In FRENCH ENGLISH summary (See N72-12492 03-18)
Avail NTIS

Nickel plated beryllium wires have been covered by an electrolytic aluminum coating with or without formerly removing the nickel layer. Diffusion phenomena have been studied by X-ray diffraction, scanning microscope examination and microprobe analysis after a series of thermal treatments of variable duration at 250 deg, 480 deg and 600 C. The recrystallization state of the wires and the matrix has been observed by X-rays. The sample structure does not undergo any noticeable modification at 250 C or for short treatments at 480 C. Author

N72-12508# Institut Superieur des Materiaux et de la Construction Mecanique, Saint-Ouen (France) Lab d Automatique et de Mecanique Vibratoire

CALCULATING AND PREDICTING VISCOELASTIC CONSTANTS OF COMPOSITE MATERIALS [SUR LES CALCULS ET LES PREVISIONS DES CONSTANTES VISCOELASTIQUES DES MATERIAUX COMPOSITES]

N ? VinhTuong *In* AGARD Composite Mater Sep 1971 28 p refs In FRENCH, ENGLISH summary (See N72-12492 03-18)

Avail NTIS

The theory of elasticity is used in conjunction with the Airy stress function to determine elastic constants of unidirectional fiber reinforced composites by computer programs In elastodynamics, dispersion relations for the propagation of elastic long waves yield elastic constants in various symmetries In viscoelasticity, upper and lower bounds are obtained separately
Author

N72-29583# Advisory Group for Aerospace Research and Development, Paris (France)

COMPOSITE MATERIALS

B Walter Rosen May 1972 125 p refs

(AGARD-LS-55) Avail NTIS HC $8 25

The material reported was assembled to support a lecture series presented in Oslo (Norway), Lyngby (Denmark) and Lisbon (Portugal) in June 1972 The objective of the lectures was to present the modern composites concept, a review of materials for advanced composites (fibers reinforced plastics, metal matrix composites) Considerations in the application of advanced composites and airframe application are covered For individual titles, see N72-29590 through N72-29596

N72-29590 Materials Sciences Corp , Blue Bell Pa

DESIGN OF COMPOSITE MATERIALS

Walter Rosen *In* AGARD Composite Mat May 1972 22 p refs (For availability see N72-29589 20-18)

Studies of the relationships between the effective properties of fiber composite materials and the mechanical and geometric properties of their constituents are reviewed The aims of such studies are, first, to provide the ability to analyze the performance of structures utilizing these heterogeneous materials and second, to provide guidelines for the development of improved materials The rationale for designing a material to suit the application is described The feasibility of accomplishing this aim through the use of high stiffness and high strength filamentary materials is discussed It is emphasized that the design cycle with composites involves many more steps than the equivalent metallic structural design process The relationship is developed governing the thermomechanical properties of composites The importance of heterogeneity and anisotropy are treated Theoretical results are presented for composite elastic moduli, thermal expansion coefficients, thermal conductivities and specific heats Results are presented in a form easily usable for parametric study of candidate materials during the preliminary design phase The status is discussed of the understanding of the tensile compressive and shear strengths of unidirectional composites The definition of the mode of failure is emphasized
Author

N72-29591 Rensselaer Polytechnic Inst Troy, N Y Materials Div

FIBER AND MATRIX MATERIALS FOR ADVANCED COMPOSITES

P J Dieferdorf *In* AGARD Composite Mat May 1972 20 p refs (For availability see N72-29589 20 18)

Composite materials provide a solution for the engineering use of high specific strength high specific modulus, but brittle materials These brittle materials are used as fibrous reinforcement to provide strength and stiffness in the composite The fundamental principles for selecting the reinforcements are described, as well as the concepts used to form these materials into high strength filament Detailed information on the preparation structure and properties of boron carbon and organic filament are presented Matrix materials, which are used to transfer stress to the fiber and also prevent brittle failure, are discussed in less detail The techniques for combining filaments and matrix into prepreg or other preforms and the fabrication into structure are considered Finally the mechanical properties of composites based on boron, carbon, and organic fibers are presented
Author

N72-29592 General Dynamics, Fort Worth, Tex

COMPOSITES IN THE STRUCTURAL DESIGN PROCESS

M E Waddoups *In* AGARD Composite Mat May 1972 13 p refs (For availability see N72-29589 20-18)

The use of advanced composites as a primary structural material for aircraft structures has required alteration of the characterization and design process Specific departures from conventional lightweight metal design practices have resulted because of the fabrication and process control characteristics the failure characteristics of the material, and the additional structural design variables Each of these subject areas with the attendant impact of composite materials on design practice are reviewed Case examples for actual prototype hardware are presented
Author

N72-29593 National Physical Lab , Teddington (England) Div of Materials Applications

EXPERIMENTAL METHODS FOR COMPOSITE MATERIALS

B E Read and G D Dean *In* AGARD Composite Mat May 1972 28 p refs (For availability see N72-29589 20-18)

A wide range of techniques is discussed for measuring the elastic, viscoelastic, ultimate strength, thermal and electrical properties of fiber reinforced composites Main emphasis is given to the determination of the basic properties of unidirectionally reinforced composites and for this purpose, the mechanical test samples considered are mainly in the form of rectangular bars However some consideration is given to methods involving honeycomb sandwich structures, circular rods, plates, rings and cylinders For determining the state Youngs moduli and Poissons ratios tensile and compressive tests are considered in addition to flexure methods (cantilever, 3-point and 4-point) and also the honeycomb sandwich technique Methods for measuring the shear moduli include both torsion and off-axis tensile tests Comparative elastic data obtained by these methods are collected and discussed for unidirectional silica fiber-epoxy, carbon fiber-epoxy boron fiber epoxy and boron fiber-aluminum composites Creep and stress relaxation methods are outlined for studying time dependent viscoelastic behaviour and results illustrated for nylon-rubber and boron-epoxy composites Several dynamic tests are described including the low frequency forced nonresonance torsion pendulum, audiofrequency resonance and ultrasonic pulse techniques Dynamic elastic constants and damping factors are illustrated for carbon fiber-epoxy composites as a function of frequency and fiber volume fraction Methods are assessed for determining the tensile, compressive, flexural and shear strength fracture energy and fatigue life, and selected data are illustrated for some carbon fiber, boron fiber and glass fiber composites Techniques for measuring the thermal expansion coefficient, thermal conductivity, heat capacity electrical resistivity, dielectric constant and loss are outlined and some results presented for unidirectional carbon fiber composites Brief mention is made of magnetoresistive and thermomagnetic data obtained on a composite formed by the unidirectional solidification of an eutectic InSb NiSb mixture
Author

N72-29594 General Dynamics Fort Worth, Tex

AUTOMATED DESIGN AND FUTURE DESIGN TRENDS

M E Waddoups *In* AGARD Composite Mat May 1972 10 p refs (For availability see N72-29589 20 18)

Examples of the new class of key composites related optimization problems are presented accompanied by illustrations of the application of modern optimization methods to composite design problems
Author

N72 29595 British Aircraft Corp Warton (England) Military Aircraft Div

GENERAL CONSIDERATIONS IN THE APPLICATIONS OF ADVANCED COMPOSITES

I C Taig *In* AGARD Composite Mat May 1972 14 p refs (For availability see N72 29589 20 18)

The characteristics of advanced composites are compared with those of conventional airframe materials It is shown that many considerations other than conventional mechanical properties and fabrication technology influence the selection and realization of effective applications of composites Particular attention is given to the assessment of cost effectiveness to the achievement of integrity in a broad sense including protection against adverse environmental effects and to some practical aspects of producibility Trends in material and manufacturing costs are presented to show that in the airframe industry most parts of the structure could benefit from the extensive use of composites in the next ten years Expansion and redirection of the research and development effort will be needed to exploit the economic potential of the materials Author

N72 29596 British Aircraft Corp Warton (England) Military Aircraft Div

AIRFRAME APPLICATIONS OF ADVANCED COMPOSITES

I C Taig *In* AGARD Composite Mat May 1972 12 p refs (For availability see N72 29589 20 18)

A wide variety of primary and secondary structural applications of advanced composites are presented It illustrates using actual or projected examples the progressive introduction into service of components of increasing complexity and cost effectiveness All previously unpublished information relates to carbon fiber epoxy composites under development in the U K but to broaden the picture the coverage also includes boron epoxy carbon epoxy and to a lesser extent boron aluminum applications in the U S A The range of components covered includes composite reinforced metal members sandwich panel structures such as doors floors and control surfaces rod and the tube members box structures such as tail surfaces and wings frames bulkheads and fuselage shell structures Particular emphasis is given to the design principles and practical features embodied in each application illustrating as far as possible the general considerations of the previous paper Where information is available mass savings and cost effectiveness data are quoted and comments on the operating environment and experience in service are included Author

N73-27474# Advisory Group for Aerospace Research and Development Paris (France)

IMPACT OF COMPOSITE MATERIALS ON AEROSPACE VEHICLES AND PROPULSION SYSTEMS

May 1973 288 p refs In ENGLISH and partly in FRENCH Presented at Joint Symp of the AGARD Structures and Mater Panel and Propulsion and Energetics Panel Toulouse 20 22 Sep 1972

(AGARD CP 112) Avail NTIS HC $16 50

The proceedings of a conference on the use of composite materials in the construction of aerospace vehicles and propulsion systems are presented The subjects discussed include the following (1) mechanical properties of high performance plastic composites (2) design concepts using composites in airframes (3) design and manufacturing aspects of composite materials with organic matrices (4) application of advanced fibrous composites to aeronautical gas turbine engines and (5) failure analysis of fiber reinforced composite motor case

N73-27475 Air Force Materials Lab Wright Patterson AFB Ohio Nonmetallic Materials Div

MECHANICAL PROPERTIES OF HIGH PERFORMANCE PLASTIC COMPOSITES

Theodore J Reinhart Jr *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 27 p refs (For availability see N73 27474 18 18)

Data and information are presented on high strength high modulus reinforcing fibers and organic resin composites fabricated from these fibers Glass boron graphite various metallic PRD 49-III and silicon carbide fiber and composite properties are discussed Combined fiber or hybrid composites containing boron and S-glass and beryllium fibers and S-glass are discussed The properties of the various forms of asbestos reinforcements are presented along with the mechanical properties of several asbestos reinforced epoxy resin composites Fatigue creep and stress rupture data are presented where data on similar composite constructions could be found in the literature Author

N73-27476 Deutsche Forschungs und Versuchsanstalt fuer Luft- und Raumfahrt Stuttgart (West Germany) Inst fuer Bauweisen- und Konstruktionsforschung

FIBER REINFORCED MATERIALS FOR APPLICATION IN THE COLD PART OF TURBINE ENGINES

Gerhard Grueninger and Richard Kochendoerfer *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 13 p refs (For availability see N73 27474 18 18)

The strength to density ratio property of fiber reinforced materials with plastic and metallic matrix is discussed The properties of fibrous materials used in structures which are submitted to uniaxial loads are analyzed The use of composite materials for blades and discs of turbine engines for operation at elevated temperatures is analyzed Author

N73-27477 Hawker Siddeley Aviation Ltd Woodford (England)

CARBON FIBRE COMPOSITES PROMISES AND PROBLEMS

W G Heath *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 11 p refs (For availability see N73 27474 18 18)

Structures of carbon fiber composite show great promise in reduction of weight and freedom from fatigue and corrosion They also permit the designer to tailor the material to match the applied loading There are on the other hand serious problems to be overcome the high cost of the material its brittle nature its susceptibility to erosion and its lack of robustness the variability between apparently identical components and the difficulty of making joints between sub assemblies This paper examines the promises and problems in turn it shows how the promising features might be exploited more fully and seeks solutions to the problems Author

N73 27478 Naples Univ (Italy)

PRODUCTION OF FIBROUS METAL COMPOSITES BY POWDER ROLLING

I Crivelli Visconti P Jauch (Aeritalia Naples) and C Voto (Aeritalia Naples) *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 23 p refs (For availability see N73 27474 18 18)

The fundamental aspects of powder rolling are considered regarding both the production of continuous strips starting from metal powder and the production of fibrous metal composites obtained by contemporary rolling of powder with strong reinforcing wires The method can be applied to a large number of matrix fibers systems of aeronautical interest After a description of the influence of each parameter regulating the physical properties of the green strip like roll gap feeding system type and size of powder roll diameter number of fibers some of theoretical and experimental properties of systems of practical interest are reported From the results obtained during the entire work on the described method the actual potential and advantages of this method of metal composites fabrication is discussed in relation to other similar methods and a few examples of possible applications are given Author

N73 27479 British Aircraft Corp Preston (England) Military Aircraft Div

DESIGN CONCEPTS FOR THE USE OF COMPOSITES IN AIRFRAMES

I C Taig *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 18 p refs (For availability see N73 27474 18 18)

A philosophy for design of filamentary composite components

emphasising integrity and cost effectiveness is outlined This involves intensive development of a limited number of basic structural concepts Several such concepts applicable to airframe structures are reviewed starting with a simplified assessment of their structural efficiency (measured in terms of mass saving, and including a brief discussion of features relating to integrity and fabrication The review includes composite reinforcement of metal structures solid rods tubes and beams sandwich skin panels and sandwich box structures stiffened skins and wound tubes and lattices Particular attention is given to attachments and load introduction and a brief section deals with bonded and mechanical joints The paper concludes with illustrations of structures embodying some of the concepts described Author

N73-27480 Air Force Flight Dynamics Lab Wright Patterson AFB Ohio
DESIGN AND FAILURE CRITERIA OF ADVANCED COMPOSITE PRIMARY STRUCTURE
Larry G Kelly *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion systems May 1973 8 p (For availability see N73-27474 18-18)

The design, fabrication, and flight test of a boron/epoxy F-111 stabilizer are discussed The applicability of this composite material to airframe construction and the ability to achieve significant weight savings are reported The material allowables and design philosophy utilized in the evolution of this structure are employed as an example of an approach to establishing logical failure criteria from which efficient designs can be developed with continuous aligned high modulus high strength composite materials One of the outstanding features of filamentary composite materials is their directional properties which provides the ability through crossplying of lamina to tailor a structure which meets specific loads and/or stiffness requirements with a minimum amount to material and weight Thus a more efficient and reliable method of establishing design allowables for all laminates of interest was developed The approach selected was to experimentally determine the stress-strain response to simple unidirectional laminae at the required design temperature and with the aid of a mathematical model establish a failure envelope to serve as the designers tool for selection of a suitable laminate thickness and ply orientation for a given set of load conditions Author

N73-27481 Stuttgart Univ (West Germany)
PRESENT AND FUTURE POSSIBILITIES OF HIGH STRENGTH AND STIFFNESS-TO-WEIGHT RATIO COMPOSITES IN PRIMARY STRUCTURES
Ulrich Huetter *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 14 p refs Prepared in cooperation with DFVLR, Stuttgart (For availability see N73-27474 18-18)

The application of composite materials to primary aircraft and spacecraft structures is discussed Some of the limitations which affect the use of the composite materials for certain purposes are described The mechanical and physical properties of shell structures are reported A hypothesis for composite material failure is developed Charts graphs and diagrams are included to clarify the theoretical concepts Author

N73-27482 Messerschmitt-Boelkow-Blohm G m b H Ottobrunn (West Germany)
APPLICATION OF COMPOSITE MATERIALS FOR AEROSPACE STRUCTURES
F Och and W Jonda *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 10 p refs (For availability see N73-27474 18-18)

The use of reinforced composite materials for aerospace structures is discussed Component developments for the application of various composites such as glass carbon and PRD as well as combinations of glass and carbon are reviewed An example of an all-glass composite used in a third stage of a rocket launcher is presented The application of all-carbon composites for helicopter rotor blades is reported The mechanical and physical properties of PRD-49 organic fiber are analyzed Author

N73-27483 Westland Helicopters Ltd Hayes (England)
USE OF COMPOSITES IN HELICOPTERS. ADVANTAGES AND DISADVANTAGES
H F Winny *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 9 p refs (For availability see N73-27474 18-18)

A survey is given of the use of glass and carbon fiber composite materials for helicopter structures It is reported that glass reinforced plastics should be used on rotorheads of the semi-rigid types and on rotor blades where fatigue strength and low stiffness and density are required to save weight Carbon fiber reinforced plastics are recommended for the main helicopter structures A summary of the strength and stiffness properties of both types of composites is presented Methods of overall fabrication for cost effective materials are proposed Author

N73-27484 Societe Nationale Industrielle Aerospatiale, Courbevoie (France) Dept Structures Nouvelles
COMPOSITES IN ENGINE STRUCTURES AND THEIR ADAPTATION TO AERONAUTICAL NEEDS [LES COMPOSITES DANS LES STRUCTURES D'ENGINS ET LEUR ADAPTATION AUX BESOINS AERONAUTIQUES]
G Jube *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 10 p In FRENCH (For availability see N73-27474 18-18)

The use of highly rigid composite materials in aircraft structures particularly engine structures is examined A detailed review was made of the use of reinforced boron and carbon filaments A comparison was also made of the fatigue life of the two materials Transl by E H W

N73-27485* National Aeronautics and Space Administration Langley Research Center Langley Station Va
APPLICATION OF COMPOSITES TO THE SELECTIVE REINFORCEMENT OF METALLIC AEROSPACE STRUCTURES
W A Brooks Jr E E Mathauser, and R A Pride *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 15 p refs (For availability see N73-27474 18-18)
CSCL 11D

The use of composite materials to selectively reinforce metallic structures provides a low cost way to reduce weight and a means of minimizing the risks usually associated with the introduction of new materials An overview is presented of the NASA Langley Research Center programs to identify the advantages and to develop the potential of the selective reinforcement approach to the use of composites These programs have shown that selective reinforcement provides excellent strength and stiffness improvements to metallic structures Significant weight savings can be obtained in a cost effective manner Flight service programs which have been initiated to validate further the merits of selective reinforcement are described Author

N73-27486 Technische Universitaet Brunswick (West Germany) Inst fuer Flugzeugbau und Leichtbau
EXPERIENCE WITH COMPOSITES AS OBTAINED FROM GLIDERS
W F Thielemann *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 7 p (For availability see N73-27474 18-18)

A survey is given of the design and manufacture of gliders using glass fiber and carbon fiber reinforced plastic composites for primary structures The two main advantages cited are (1) the possibility of getting very smooth surfaces of high aerodynamic quality and (2) the possibility of reducing the fabrication costs by producing large integral structures instead of assembling many prefabricated metallic structural details The design problems structural problems and performance test data for reinforced plastic construction are reported Author

N73-27487 Army Air Mobility Research and Development Lab., Fort Eustis, Va. Structures Div.
ADVANCES IN BALLISTICALLY TOLERANT FLIGHT CONTROLS
I. E. Figge, Sr. *In* AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems May 1973 8 p refs (For availability see N73-27474 18-18)

Combat data indicate that helicopter flight control components are exceptionally vulnerable to catastrophic failure upon ballistic impact. The ballistic tolerance approach, which is to design the critical components to function after ballistic penetration, offers a solution to reduce vulnerability. Studies have shown that this approach can virtually eliminate catastrophic failure while achieving substantial weight saving and reduced production costs. Limited data indicate this approach is also adaptable to flight control bearings and attachments. Venting was found to reduce the damage on the exit side of sandwich structures and preslotting was found to prevent delamination of the exit face in the area of impact. Author

N73-27488 Royal Aircraft Establishment, Farnborough (England). Structures Dept.
INSTABILITY OF LAMINATED COMPOSITE PLATES
G. Z. Harris *In* AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems May 1973 19 p refs (For availability see N73-27474 18-18)

The response of general laminated plates to applied loading exhibits a coupling between bending and extensional modes of deformation. Such a laminate will for example undergo a bending response when load is applied in the plane of the laminate. Such coupling may be significant when shear or compressive loads are applied in-plane since the additional deformation modes may reduce the buckling load or affect the post-buckling stiffness of the laminate. The present paper considers the stiffness immediately after buckling of two types of panel which undergo bifurcational buckling. The first class of panel considered is one of angle-ply type. A solution is derived for the initial buckling of a rectangular panel to which is applied a constant end displacement. The pre-buckling response is one which exhibits no out of plane displacements, although the initial buckling load is affected by the existence of out-of-plane coupling. The second class of panel is of cross-ply type, the buckling loads being derived for a long panel having a constant strain edge member and subjected to end load. Author

N73-27489 Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost.
DESIGN AND MANUFACTURING ASPECTS OF COMPOSITE MATERIALS WITH ORGANIC MATRICES FOR APPLICATION AT HIGH TEMPERATURES
J. J. Cools *In* AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems May 1973 15 p refs (For availability see N73-27474 18-18)

Some design and manufacturing aspects are presented of the mixed structure concept which was developed for application in aerospace structures subjected to high temperatures. In this concept a HM-composite material with an organic matrix is laminated between metallic faces to combine simultaneously the favorable features of both types of materials. The HM-composite material is the main load carrying component. The metallic faces protect the organic matrix against oxidation by air at high temperatures, provide an electrically conductive surface of the structure and contribute to stabilization against buckling. The mixed structure concept can also be applied to aerospace structures subjected to normal operating temperatures. Author

N73-27490 National Gas Turbine Establishment, Pyestock (England).
A LIMITED REVIEW OF THE APPLICATION OF ADVANCED FIBROUS COMPOSITES TO AERO GAS TURBINE ENGINES
A. W. H. Morris *In* AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems May 1973 16 p refs (For availability see N73-27474 18-18)
CSCL 11D

A review of fiber reinforced composite material relevant to aero gas turbine engine application is presented for systems both commercially available and projected. Emphasis has been placed on those mechanical property requirements and fabrication problems which are peculiar to gas stream components. Although high strength and high elastic modulus composites are available in organic and inorganic matrices for low temperature application, these materials exhibit extremely poor impact and erosion characteristics which may limit use where foreign object damage is prevalent. Several engineering solutions to the problem are discussed. The application of composites in the high temperature turbine stage has difficulties such as fiber stability and thermal fatigue and is considered to be very impractical. The development of directionally solidified eutectics, which can loosely be described as composites, offers more encouragement as the next generation turbine material. Author

N73-27491* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MATERIAL AND STRUCTURAL STUDIES OF METAL AND POLYMER MATRIX COMPOSITES
Robert A. Signorelli, Tito T. Serafini, and Robert H. Johns *In* AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems May 1973 16 p refs (For availability see N73-27474 18-18)

Fiber-reinforced composites and design analysis methods for these materials are being developed because of the vast potential of composites for decreasing weight and/or increasing use temperature capability in aerospace systems. These composites have potential for use in airbreathing engine components as well as aeronautical and space vehicle structures. Refractory wire-superalloy composites for use up to 2200 F or more and metal matrix composites for lower temperature applications such as aerospace structures and turbojet fan and compressor blades are under investigation and are discussed. The development of a number of resin systems, including the polyimides and polyphenylquinoxalines, is described and their potential for use at temperatures approaching 315 C (600 F) is indicated. Various molecular modifications that improve processability and/or increase thermal and oxidative resistance of the resins are also described. Structural analysis methods are discussed for determining the stresses and deformations in complex composite systems. Consideration is also given to residual stresses resulting from the curing process and to the foreign object damage problem in fan blade applications. Author

N73-27492 Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
ELABORATION OF REFRACTORY COMPOSITE MATERIALS BY DIRECTIONAL SOLIDIFICATION [ELABORATION DE MATERIAUX COMPOSITES REFRACTAIRES PAR SOLIDIFICATION ORIENTEE]
Maurice ElGammal *In* AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems May 1973 10 p refs In FRENCH; ENGLISH summary (For availability see N73-27474 18-18)

The principles of directional solidification for producing lamellar and fibrous composite materials from eutectic alloys are discussed. Some pseudo binary eutectics and more complex alloys are compared for high mechanical strength at elevated temperatures. The properties of these materials are outlined in order to determine the use for turbine blades and vanes. Problems involved in the application of the composite materials are presented. Author

N73-27493 General Electric Co., Cincinnati, Ohio.
DIRECTIONALLY SOLIDIFIED EUTECTICS IN GAS TURBINE DESIGN
L. P. Jahnke, H. J. Brands, and G. D. Oxx, Jr. *In* AGARD Impact of Composite Mater. on Aerospace Vehicles and Propulsion Systems May 1973 9 p refs (For availability see N73-27474 18-18)

Composite structures consisting of high strength fibers or plates in ductile matrices with outstanding high temperature properties are achievable in directionally solidified eutectics. This new class of materials represents a major innovation in gas turbine blade technology. The advantages and limitations of the

two more promising eutectics systems and the relationship of these properties to turbine blade design is discussed Innovations in design and further property improvements will be required to successfully exploit these materials in engine hardware It is concluded that the payoff offered by this technology fully justifies a major investment of resources to achieve a practical system Author

N73-27494 Motoren- und Turbinen-Union Muenchen G m b H (West Germany)
EUTECTIC ALLOYS WITH UNI-DIRECTIONAL SOLIDIFICATION. STUDY ON THEIR USE FOR TURBINE BLADES c17
H Huff and W Betz *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 6 p refs (For availability see N73-27474 18-18)

The principle of directional solidification of eutectic alloys is briefly shown and the influence of temperature gradient solidification rate and impurities is described Using a list of the most important demands on turbine blade materials the merits and demerits of directionally solidified eutectics for this purpose are discussed It seems that there are good chances for utilizing this compound material for gas turbines There will be however a lot of further investigations necessary especially with respect to casting technology Author

N73-27495 Rolls-Royce Ltd Bristol (England) Engine Div
POTENTIAL USE OF COMPOSITE MATERIALS FOR GAS TURBINE STATIC STRUCTURES
J W Sharp and L Battezzato (Fiat S P A) *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 14 p refs (For availability see N73-27474 18-18)

The applications of composite materials on a number of static gas turbine components and assessment of these components have shown that they can be made lighter than their metal design equivalent Cost savings in some cases could also be expected although some improved manufacturing techniques are necessary The materials considered are primarily glass and carbon fiber reinforced structures with a working temperature up to 250 C Experience with such composite structures are reviewed including failures and successes Author

N73-27496 Societe Nationale d Etude et de Construction de Moteurs d Aviation, Corbeil (France)
APPLICATION OF THE BASE COMPOSITES OF CARBON FIBERS AND BORON WIRE TO COMPRESSOR BLADES [APPLICATION DE COMPOSITES A BASE DE FIBRES OF CARBONE ET DE FILS DE BORE AUX AUBES DE COMPRESSEUR]
P Lesrop and R Chevalier *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 8 p In FRENCH (For availability see N73-27474 18-18)

A critical summary was made of the fabrication of compressor blades from metallic composites The mechanical resistance vibration characteristics fatigue, and erosion properties of carbon epoxy, boron epoxy, boron aluminum composite blades were examined Performance tests results are given in tables Transl by E H W

N73-27497 Air Force Aero Propulsion Lab Wright-Patterson AFB Ohio
FATIGUE TOLORANCE OF DAMAGED METAL COMPOSITE BLADING
T J Norbut *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 10 p refs (For availability see N73-27474 18-18)

The successful exploitation of the lightweight high specific strength and modulus features of metal matrix composite systems in turbine engine blading rests heavily on the realistic assessment of the materials inherent tolerance to sustain damage from foreign objects ingested into the engine The spectrum of foreign object debris typically contained in military and commercial engine specifications is summarized to obtain a perspective of the debris characteristics a turbine engine is expected to ingest and reliably tolerate The scope of these specifications served as the basis for the development of a damage simulation technique for a specific class of foreign object debris 403 stainless steel and Ti 6Al-4V blades damaged with this technique were compared to typical field damage blades and found to correlate favorably The technique was subsequently utilized to damage representative Boron/Aluminum airfoil specimens for evaluation of fatigue strength degradation effects It was concluded that Boron/Aluminum possessed a considerably lower notch sensitivity in high cycle fatigue when compared to the notched fatigue characteristics of homogeneous blade materials Author

N73-27498 Pratt and Whitney Aircraft, East Hartford, Conn
BORON-POLYIMIDE REINFORCED TITANIUM FAN DISKS
Hans Stargardter and Karl Jakobsen *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 10 p (For availability see N73-27474 18-18)

The design, fabrication, and testing of boron-polyimide reinforced titanium fan disks having a temperature capability of 600 F are described The high modulus and low density of this material allow for a redesign of the fan disk with a reduction in weight of 36% compared to the conventional design Processing techniques involving filament winding and resin curing were developed on 10 inch diameter hoops Two fullscale disks were fabricated and evaluated through spin testing to 600 F Author

N73-27499 Societe Nationale d Etude et de Construction de Moteurs d Aviation, Villaroche (France) Dept Resistance des Materiaux
STUDY OF DISK BINDING OF COMPRESSORS BY BASE COMPOSITES OF BORON WIRE [ETUDE DU FRETTAGE DES DISQUES DE COMPRESSEUR PAR DES COMPOSITES A BASE DE FIL DE BORE]
Claude Stoltz *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 8 p In FRENCH (For availability see N73-27474 18-18)

A theoretical study was made of the general principles of binding compressor disks with boron composites Data cover possible weight reductions and peripheral speed augmentation Crack and endurance tests are also made The results are compared with predictions Transl by E H W

N73-27500 Army Missile Command, Redstone Arsenal, Ala
FAILURE ANALYSIS OF A FIBER REINFORCED COMPOSITE MOTOR CASE USING DISTORTIONAL ENERGY AND MAXIMUM STRAIN THEORIES OF FAILURE
Richard J Thompson, John W Sofferis, and Charles M Eldridge *In* AGARD Impact of Composite Mater on Aerospace Vehicles and Propulsion Systems May 1973 3 p refs (For availability see N73-27474 18-18)

A method of determining the failure condition of a fiber reinforced composite structure is extended for application to an actual design and analysis problem The original method uses the distortional energy and maximum strain theories of failure A finite element stress analysis program was modified for application to fiber composites This work extends the failure program to include helical tubes The method of calculation of wrap angle is altered after first stage yielding as pressure increments are increased Provision was made to automatically update the displacement field After each loading increment, the displacement field is calculated and the new values are added to the old ones Author

19 MATHEMATICS

Includes calculation methods and theory and numerical analysis. For applications see specific categories. For related information see also 08 Computers.

No abstracts in this subject category

20 METEOROLOGY

Includes climatology weather forecasting and visibility studies For related information see also 13 Geophysics and 30 Space Sciences

N72-11811# Advisory Group for Aerospace Research and Development, Paris (France)
A SUMMARY OF ATMOSPHERIC TURBULENCE RECORDED BY NATO AIRCRAFT
Cyril G Peckham (Technology, Inc, Dayton, Ohio) Sep 1971 133 p refs
(Contract AGARD-OTAN LMP 67-68)
(AGARD-R-586-71 UDC-551 551 5) Avail NTIS

A summary and analysis of flight-measured cumulative acceleration distributions due to atmospheric turbulence are presented Data from 37 different aircraft was processed A description of the recording systems and the methods of data processing is given The power spectral density methods to derive gust velocities is detailed Author

N72-21690# Advisory Group for Aerospace Research and Development, Paris (France)
ATMOSPHERIC POLLUTION BY AIRCRAFT ENGINES AND FUELS, A SURVEY
Robert F Sawyer (Calif Univ, Berkeley) Mar 1972 40 p refs
(AGARD-AR-40) Avail NTIS

A survey of atmospheric pollution by aircraft engines, aircraft fuels, and related research work was conducted among several European nations and the United States Twenty-seven current or potential problem areas are described Of these areas, the five most pressing are (1) engine emission characteristics, (2) test procedures, (3) nitric oxide formation, (4) carbon monoxide and hydrocarbons at low power, and (5) effect of high altitude emissions It was recommended that research be encouraged in all 27 areas, although in some cases only a better definition of the nature of the problem as opposed to a solution may be required A selected but extensive bibliography is provided in the appendix Author

N74-14271# Advisory Group for Aerospace Research and Development, Paris (France)
ATMOSPHERIC POLLUTION BY AIRCRAFT ENGINES
Sep 1973 405 p refs Mostly in ENGLISH partly in FRENCH Conf held at London 9-13 Apr 1973
(AGARD-CP-125) Avail NTIS HC $22 25

The proceedings of a conference on the effects of aircraft engines on atmospheric pollution are presented The impact of military and civilian aircraft operations on pollution levels are compared with the pollution from other sources The subjects stressed are (1) effects of pollution at very high altitudes (2) effects of pollution near airports, and (3) methods for reduction of pollutant production in combustion processes and in engines A review of the physiological effects of air pollution is included For individual titles see N74-14272 through N74-14306

N74-14272* New York Univ N Y Dept of Aeronautics and Astronautics
REDUCTION OF NO FORMATIONS BY PREMIXING
Antonio Ferri In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 10 p ref (For availability see N74-14271 05-20)
(Grant NGR 33-016-131)

The effects of exhaust gases from supersonic transport aircraft on the equilibrium of the stratosphere are discussed A method for reducing the amount of nitrogen oxides generated by the engines of supersonic transports is describes The engine requirements for the turbojet engines of the supersonic transport aircraft are defined The design of combustion chambers to provide premixed flames and the thermodynamic properties of premixed flames are analyzed Charts are developed to show the isotherms of the ignited mixtures for various conditions and the mass fraction of nitrogen oxide along selected streamlines Author

N74-14273 Department of Transportation Washington D C
UNITED STATES DEPARTMENT OF TRANSPORTATION RESEARCH PROGRAM FOR HIGH ALTITUDE POLLUTION
Alan J Grobecker In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 13 p refs (For availability see N74-14271 05-20)

A review of a United States program to provide an assessment by 1974 of the impact on man plants and animals of climatic changes due to parturbations of the upper atmosphere by the propulsion effluents of a world high altitude aircraft fleet as projected to 1990 is presented Some physical considerations which must be taken into account in this program are described including representations of the stratosphere in its unperturbed state, of the effluents of vehicles expected in 1990 of the perturbed stratosphere of 1990 of the perturbed troposphere of 1990 and 2020 of the effects of climatic changes on the biosphere and of social and economic measures of these biological effects Author

N74-14274 California Univ Berkeley Dept of Chemistry
REACTION OF OZONE WITH NITROGEN OXIDES AT HIGH ALTITUDES
Harold S Johnston and Gary Whitten In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 13 p refs Sponsored by DOT (For availability see N74-14271 05-20)

Ozone formation in the stratosphere by the dissociation of oxygen by ultraviolet radiation below 242 nm is discussed Ozone is removed from the stratosphere by (1) the reaction of oxygen atoms and ozone (2) by transport to the troposphere (3) by catalytic reactions with free radicals based on water and (4) by catalytic reactions with the oxides of nitrogen The most important factor in the natural removal of stratospheric ozone appears to be catalytic cycles based on the oxides of nitrogen The natural source strength has been calculated by three different investigators There is about a factor of four uncertainty in the natural rate of injection of nitric oxide in the stratosphere There is about a factor of four uncertainty in the calculated rate of introduction of nitric oxide in the stratosphere from full scale operation of supersonic transports of current and past designs Within these two ranges of uncertainty, 500 supersonic transports would introduce nitric oxide in the stratosphere at a rate comparable to the known natural sources Author

N74-14275 Meteorological Office (Gt Brit)
NITROGEN OXIDES, NUCLEAR WEAPON TESTING, CONCORDE AND STRATOSPHERIC OZONE
P Goldsmith, A F Tuck, J S Foot, E L Simmons, and R L Newson In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 15 p refs (For availability see N74-14271 05-20)

The attenuation of the earth's ozone shield and an increase in the ultraviolet radiation reaching the planetary surface because of aircraft engine exhaust products is examined It is stated that insufficient investigation has been made of the effects of radiation photochemistry and atmospheric circulation on the ozone content The introduction of nitrogen oxides into the stratosphere through nuclear tests is compared with the amount expected from aircraft operations Emphasis is placed on the chemical kinetics of heated air The chemical processes used in calculating the nitrogen oxide production in the hot air masses created by the nuclear shock wave are analyzed Author

N74-14276 Pratt and Whitney Aircraft East Hartford Conn
DETAILED EXHAUST EMISSION MEASUREMENTS OF THREE DIFFERENT TURBOFAN ENGINE DESIGNS
A W Nelson In AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 13 p refs (For availability see N74-14271 05-20)

A series of test programs was conducted to better define the exhaust emission characteristics of three different aircraft engine models the JT3D a low bypass ratio turbofan engine the JT8D a mixed flow turbofan engine and the JT9D a high bypass ratio turbofan engine Special investigations were conducted on the JT3D and JT9D engines to investigate inlet temperature and humidity effects Analysis of these data was supplemented with previously obtained data in order to increase the range of variables investigated For the mixed flow JT8D

engine special tests were conducted using an engine especially modified to physically separate the fan and core engine streams so that true undiluted emission measurements could be obtained Three different methods were used to evaluate the emission levels of each engine model multipoint rake, exhaust case pressure probes and super detailed traversing Analysis of the latter method produced highly refined contour plots of CO THC and NOX emission footprints as well as exhaust temperature and pressure variations at the plane of the tailpipe The average emission levels obtained by each of the three measurement methods are compared Author

N74-14277 Bonn Univ (West Germany) Inst fuer Physikalische Chemie

PHOTO-OXIDATION OF AIRCRAFT ENGINE EMISSIONS AT LOW AND HIGH ALTITUDES

K H Becker and U Schurath *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 9 p refs (For availability see N74 14271 05 20)

The mechanism of photochemical smog formation is examined The applicability of photochemical smog formation to aircraft emissions is described It is concluded that photo oxidation mechanisms of pollutants from aircraft and other sources in the troposphere undergo fundamental changes with altitude radical and atom reactions and probably reactions of metastable oxygen molecules becoming more important in the colder regions of the troposphere Serious contamination of the troposphere by aircraft is not expected, because the residence time of pollutants is short compared with emissions rates Author

N74-14278 Oslo Univ (Norway) Inst of Geophysics

EFFECT OF SUPERSONIC TRANSPORT UPON THE OZONE LAYER, STUDIED IN A TWO-DIMENSIONAL PHOTOCHEMICAL MODEL WITH TRANSPORT

Eigil Hesstvedt *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 8 p refs (For availability see N74 14271 05 20)

A steady state two-dimensional model of the stratospheric ozone layer is presented Photochemical reactions involving oxygen, hydrogen, and nitrogen are considered along with the effect of a parameterized two dimensional transport, by mean motion and by eddies A parameterized meridionel distribution of NOx is applied, computed from one dimensional models The model is in fair agreement with observed ozone data The reduction of ozone from emission of NOx from supersonic aircraft is studied, assuming a fleet of 200 aircraft flying at given altitudes and uniformly distributed over the globe The effect is found to depend critically upon the flight level For mid latitude summer, the ozone column density is reduced by 0.4% for a flight level of 18 km For flight levels 23 km and 28 km the reduction is 1.6% and 2.3%, respectively Accordingly, the increase in UV radiation amounts to approximately 0.8%, 3.2%, and 4.6% for the same flight levels Author

N74-14279 Institut d'Aeronomie Spatiale de Belgique, Brussels

CHEMICAL KINETIC IN THE STRATOSPHERE

G Brasseur *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 13 p refs (For availability see N74 14271 05 20)

The production of ozone in the stratosphere by photodissociation of molecular oxygen is discussed The specific chemical reactions are analyzed to identify the components involved and the reaction kinetics for various regions of the atmosphere It is concluded that hydrogen compounds play a significant role in the formation of nitric acid and atmospheric chemical reactions must account for the formation and destruction of hydroxyl and hydroperoxyl radicals Author

N74-14280 Deutsche Forschungs und Versuchsanstalt fuer Luft und Raumfahrt Stuttgart (West Germany) Inst fuer Reaktionskinetik

A NEW ANALYTICAL TECHNIQUE FOR CONTINUOUS NO DETECTION IN THE RANGE FROM 0 1 TO 5000 PPM

H Meinel and Th Just *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 5 p refs (For availability see N74 14271 05 20)

An analytical technique for the continuous detection of small amounts of nitrogen oxide is described The process is applied to analyzing the amount of nitrogen oxides in engine exhaust gases A schematic diagram of the ultraviolet resonance absorption nitrogen oxide detector is provided It is stated that in terms of sensitivity the new method is superior to conventional continuum absorption techniques in the ultraviolet and infrared regions by a factor of ten to thirty Author

N74-14281 Bristol Univ (England) Dept of Aeronautical Engineering

PROBLEMS OF CHEMICAL POLLUTION BY AIRCRAFT. THE AIRPORT AND ITS IMMEDIATE ENVIRONMENT

T V Lawson *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 3 p (For availability see N74 14271 05 20)

The chemical pollution of the airport and its environment is discussed It calls for a careful study of all surveys so that the inbuilt implications of the model are obvious and it concludes that the problems of chemical pollution by the aircraft themselves are small It suggests that much more progress will be made in attempts to reduce pollution around airports by concentrating upon organizations other than the engine manufacturers It closes by suggesting that authors of technical papers be encouraged to supply an epilogue in which they summarize the findings of their work for the benefit of the lay public Author

N74-14282 Warren Spring Lab Stevenage (England) Air Pollution Div

RELATIVE AIR POLLUTION EMISSIONS FROM AN AIRPORT IN THE UK AND NEIGHBOURING URBAN AREAS

A W C Keddie J Parker and G H Roberts *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 9 p refs (For availability see N74 14271 05 20)

Air pollution levels at Stansted Airport in relation to emissions from four nearby towns are discussed Calculations have been made of pollution emissions from these four sources and also from the airport and the expected contributions from these sources at three local sites have been examined These values are compared with actual measurements at the three sites Author

N74-14283 Chemical Defence Experimental Establishment, Porton (England)

GROUND CONTAMINATION BY FUEL JETTISONED FROM AIRCRAFT

N L Cross and R G Picknett IN AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 9 p refs (For availability see N74 14271 05 20)

A study of the problem of ground pollution produced by fuel jettisoned from aircraft under emergency [illegible]itions was conducted The likely size distribution of drops [illegible]ced when fuel is jettisoned is examined The proportions of [illegible]isoned fuel which survive evaporation to reach the ground are determined It is stated that the contamination density on the ground depends on atmospheric stability, wind speed, and direction of flight relative to wind direction Data obtained from flight tests of jettisoned fuel are presented in tables and graphs Author

N74-14284 Air Corporations Joint Medical Service (BEA/BOAC), London (England)

POLLUTION LEVELS AT LONDON (HEATHROW) AIRPORT AND METHODS FOR REDUCING THEM

D M Bruton *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 6 p ref (For availability see N74-14271 05 20)

Exhaust pollution levels at Heathrow Airport, London, England were conducted Medical surveys of the interior of buildings were conducted to determine pollution levels It was determined that pollution levels are below those of many urban areas and do not appear to represent either a short or long range hazard to health Local pollution problems constitute a source of annoyance to ground personnel employed at the airport Methods for reducing the exhaust fume emission by vehicle selection, engine tuning and maintenance practices are recommended Author

N74-14285 Naval Postgraduate School, Monterey, Calif. Dept. of Aeronautics
POLLUTION CONTROL OF AIRPORT ENGINE TEST FACILITIES
D. L. Baily, P. W. Tower, and A. E. Fuhs *In* AGARD Atmospheric Pollution by Aircraft Engines Sep. 1973 32 p refs (For availability see N74-14271 05-20)

Engine test facilities are required to meet the same environmental standards as any other industrial facility. To meet the standards for smoke, noise, gaseous pollutants, etc., control equipment must be installed. Due to large mass flow rates the control equipment is expensive; careful attention to design is necessary to control costs. Pollution control forces new constraints on exhaust stack temperature, flow uniformity and pressure. Conversely, installation of pollution abatement apparatus may cause adverse operating conditions such as distorted flow into the engine and wrong augmentation ratio. The internal aerodynamics of engine test cells must be mastered to a level not possible previously. Scale models of test cells were fabricated in modules so that some 750 different combinations could be tested. Distortion at the engine face was measured and correlated in terms of component factors. Augmentation ratio and cell depression were measured. An analytical model correctly predicted the measured quantities except for distance from engine nozzle to augmenter inlet. With the data accumulated it should be possible to match pollution control requirements to test cell parameters. Author

N74-14286 Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany). Engine Development and Testing Dept.
EXHAUST EMISSION MEASUREMENTS ON THE GE T64-7 TURBOPROP ENGINE
W. Bergt, G. Kappler, and G. Meikis *In* AGARD Atmospheric Pollution by Aircraft Engines Sep. 1973 4 p refs (For availability see N74-14271 05-20)

Exhaust emission measurements have been carried out on the engine GE T64-7 with the objective to determine qualitatively the mass emission of the pollutants carbonmonoxide, unburnt hydrocarbons and oxides of nitrogen at different power ratings. Although for aircraft engine application the operating modes were just recently issued in the EPA proposed standards for control of air pollution, the engine was run through a 13-point California Test Cycle as applicable to Diesel engines for vehicles up to 6000 lb gross weight. The numerical evaluation of the measured exhaust emissions was carried out using the method of analysis established for the above mentioned test cycle. The measurements were taken for three different types of fuel: JP4, Diesel at 20 C and Diesel at 50 C. The exhaust gas sampling using heated sampling lines and the analytical system set up for the measurements were in agreement with SAE Specifications. The instruments used in the analytical system are shown. Author

N74-14287 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. fuer Reaktionskinetik
NO FORMATION IN FUEL RICH FLAMES: A STUDY OF THE INFLUENCE OF THE HYDROCARBON STRUCTURE

K. H. Eberius and Th. Just *In* AGARD Atmospheric Pollution by Aircraft Engines Sep. 1973 8 p refs (For availability see N74-14271 05-20)

The formation of nitric oxide in premixed propane, ethylene and acetylene flames at 1 atm has been measured. Large overconcentrations of NO were found in very fuel rich flames. The NO formation in flames could be reasonably separated into three classes: (1) Zeldovich mechanism with equilibrium O atom concentration, (2) Zeldovich mechanism with the remaining excess O atom concentration, and (3) other reactions involving radicals as CH, C, C2. The distinction of these classes can be made by studying the temperature dependence of the NO formation, by analysing the curvature of the NO profiles, by relating the rate of NO formation to O atom concentrations and by measuring HCN in some flames. The analysis of the temperature dependence of the NO formation in propane flames gave evidence that in these flames with stoichiometric ratios between 1.2 and 1.4 and temperatures between 1850 K and 2400 K, reaction class (c) is the main reaction channel. A comparison of flames which have the same temperature at the same mixture strength, but differ in the chemical structure of the fuel, shows higher NO concentrations for acetylene flames and somewhat smaller NO concentrations for methane flames relative to the concentrations in propane flames. Author

N74-14288 Direction Technique Avions, Paris (France). Aerospatiale
MEASURE OF MINOR CONSTITUENTS IN THE STRATOSPHERE BY CONCORDE 001 [MESURES DES CONSTITUANTS MINEURS DANS LA STRATOSPHERE PAR CONCORDE 001]
R. Joatton *In* AGARD Atmospheric Pollution by Aircraft Engines Sep. 1973 7 p refs In FRENCH (For availability see N74-14271 05-20)

The effect of aerospace vehicles on stratospheric pollution as measured by equipment onboard the Concorde 001 are discussed. Data cover carbon monoxide, several nitrogen oxides, and hydrocarbon emissions. Special attention was given to possible reductions of stratospheric ozone and the effect of such reductions on the environment. Transl. by E.H.W.

N74-14289 National Gas Turbine Establishment, Pyestock (England)
SOOT FORMATION IN RICH KEROSINE FLAMES AT HIGH PRESSURE
F. H. Holderness and J. J. Macfarlane *In* AGARD Atmospheric Pollution by Aircraft Engines Sep. 1973 9 p refs (For availability see N74-14271 05-20)

Soot appearing in gas turbine exhaust products originates within the primary flame. Model combustor experiments are summarized in which soot formation was measured in a reacting kerosine/air flame of uniform composition. Operating conditions are 6 to 21 bar and equivalence ratio 0.8 to 1.8. Chemical equilibrium was not attained for equivalence ratios much above unity. The available oxygen reacted initially with a portion of the fuel, the remainder appearing as pyrolysis product. The total amount of this material, including soot, was roughly dependent on equivalence ratio, independent of other variables. The fraction fully degraded to soot increased sharply on raising pressure from 6 to 11 bar. There was a well defined threshold of soot formation at equivalence ratio 1.3 to 1.4 in premixed flames. Soot was observed at weaker conditions than this in spray flames and the formation rate rose to approximately 10 percent of the input carbon at equivalence ratio 1.8. Author

N74-14290 Massachusetts Inst. of Tech., Cambridge. Dept. of Mechanical Engineering
SOOT OXIDATION KINETICS AT COMBUSTION TEMPERATURES
John P. Appleton *In* AGARD Atmospheric Pollution by Aircraft Engines Sep. 1973 11 p refs (For availability see N74-14271 05-20)
(Grant NSF GK-33933)

Comparisons between soot oxidation rate measurements obtained in laboratory flames and in a recent shock-tube investigation are made with previously reported measurements of the surface oxidation rate of bulk samples of pyrolytic graphite. On the basis of these comparisons it is concluded that the surface oxidation rate mechanisms for soot and pyrolytic graphite are the same and that the rates are predicted by a semiempirical expression, originally proposed for graphite oxidation, which expresses the specific surface oxidation rate in terms of the surface temperature and the gas phase partial pressure of oxygen. This expression provides a method of estimating soot oxidation rates which is suitable for use in engineering design and performance studies of most practical combustion systems such as gas turbine combustors. Author

N74-14291* Massachusetts Inst. of Tech., Cambridge. Dept. of Mechanical Engineering
PARAMETERS CONTROLLING NITRIC OXIDE EMISSIONS FROM GAS TURBINE COMBUSTORS

John B Heywood and Thomas Mikus *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 16 p refs (For availability see N74-14271 05-20)
(Grant NGR-22-009-378)

Nitric oxide forms in the primary zone of gas turbine combustors where the burnt gas composition is close to stoichiometric and gas temperatures are highest It was found that combustor air inlet conditions, mean primary zone fuel-air ratio, residence time, and the uniformity of the primary zone are the most important variables affecting nitric oxide emissions Relatively simple models of the flow in a gas turbine combustor, coupled with a rate equation for nitric oxide formation via the Zeldovich mechanism are shown to correlate the variation in measured NOx emissions Data from a number of different combustor concepts are analyzed and shown to be in reasonable agreement with predictions The NOx formation model is used to assess the extent to which an advanced combustor concept, the NASA swirl can, has produced a lean well-mixed primary zone generally believed to be the best low NOx emissions burner type Author

N74-14292 California Univ Berkeley Dept of Mechanical Engineering

FACTORS CONTROLLING POLLUTANT EMISSIONS FROM GAS TURBINE ENGINES

R F Sawyer, N P Cernansky, and A K Oppenheim *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 12 p refs (For availability see N74-14271 05 20)
(Grants AF-AFOSR-2299-72, AF-AFOSR-2200-72)

Primary pollutants emitted by aircraft gas turbine engines are carbon monoxide, hydrocarbons, aldehydes, smoke, particulates, and nitric oxide Factors controlling emissions of these pollutants are analyzed on the basis of aircraft engine exhaust composition and laboratory studies of gas turbine combustion processes Moreover, an analytical prediction of the effect of aircraft operating parameters on the emission of nitric oxide is also given The formation and destruction of these pollutants were investigated in a laboratory gas turbine combustor The oxidation of carbon monoxide, hydrocarbons and aldehydes was measured in the dilution zone where thermal quench phenomena were observed The apparent oxidation of particulates in the dilution zone was also observed The formation of nitric oxide was observed in the primary zone and in the first part of the dilution section of the combustor Operational conditions and engine parameters were studied analytically, yielding rational criteria for the prediction of their effect on the emmission of nitric oxide Author

N74-14293 Norwegian Inst for Air Research, Kjeller

A SYSTEMATIC APPROACH TO THE STUDY OF THE CONNECTION BETWEEN EMISSION AND AMBIENT AIR CONCENTRATIONS

Knut Erik Groenskei *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 10 p refs (For availability see N74-14271 05-20)

A systematic approach to study the effect of a complex source distribution on the ambient air quality is described Measurements of emission, meteorological parameters, and ambient air concentrations are used to develop a quantitative model describing the important physical and chemical processes The model is mathematically formulated in a modified form of the continuity equation for the pollution component To improve the model, regression analysis can be used An example of this approach is given in the study of air pollution in Oslo where it has been shown that a systematic vertical motion is the most important process to clean the air in Oslo during inversion situations Some comments are made on the model approach to the air pollution problem around an airfield Author

N74-14294 Office National d'Etudes et de Recherches Aerospatiales Paris (France)

THEORETICAL STUDY OF THE RESIDUAL EVOLUTION OF POLLUTING PRODUCTS IN TURBOJET EXHAUSTS

Roland Borghi *In* AGARD Atmospheric Pollution by Aircraft Engine Sep 1973 11 p refs In FRENCH, ENGLISH summary (For availability see N74-14271 05-20)

Efforts underway to predict and control the quantity of CO and NO polluting products produced by turbojet nozzle outlets are reviewed A numerical method, taking into account turbulent mixing phenomena and nonequilibrium chemical reactions, was developed Several reaction models were compared and show that CO immediately transforms into CO2 upon exhaust However, a much longer time is needed for NO to disappear Author

N74-14295 Pratt and Whitney Aircraft, West Palm Beach, Fla

DEVELOPMENT AND VERIFICATION OF AN ANALYTICAL MODEL FOR PREDICTING EMISSIONS FROM GAS TURBINE ENGINE COMBUSTORS DURING LOW-POWER OPERATION

Stanley A Mosier, Richard Roberts, and Robert E Henderson (AFAPL) *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 12 p refs (For availability see N74-14271 05-20)

A theoretical combustor model was formulated for predicting concentrations and distributions of unburned hydrocarbons, and carbon monoxide from gas turbine engine combustors Essential components of this model include an internal flowfield model, a treatment of the physical combustion process, and a treatment of hydrocarbon oxidation kinetics Model components were incorporated into a computer program with a single model structure for simplicity An experimental program was also conducted to evaluate combustor design techniques for lowering emission levels and to provide experimental data against which the theoretical model could be tested Burner exit-plane measurements of unburned hydrocarbons, carbon monoxide, nitrogen oxides, temperature, and pressure were made Predictions of exhaust species concentrations and distributions were made using the theoretical combustor model in support of the experimental program Results are discussed with respect to internal aerodynamic and chemical kinetic arguments within the framework of the theoretical formulation Author

N74-14296 Politecnico di Milano (Italy) Ist di Macchine

AN EXPERIMENTAL RESEARCH ON THE BEHAVIOR OF A CONTINUOUS FLOW COMBUSTION CHAMBER

C Casci, A Coghe, U Ghezzi, and S Pasini *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 11 p refs (For availability see N74-14271 05-20)

In relation to the combustion phenomena area, a continuous flow test bench was developed to study gas turbine combustion The feeding system provided a wide range of air-fuel ratio and working pressure for investigating different test conditions The combustion chamber was arranged to sample the gas composition in different positions, and to measure other magnitudes such as pressure and air and fuel mass flow rate The species analyzed were carbon monoxide, unburned hydrocarbon and nitrogen oxides The primary concern was the evolution of the above species along the can-type liner and the determination of optimum working conditions The typical design features of the combustion chamber described allow a comparison of the results obtained to real systems but the kinetic and fluid dynamic phenomena concerned with the combustion process make the extrapolation of the results difficult for conditions very far from the experimental ones in this research Author

N74-14297 Air Force Dept Washington, D C

SESSION 4 DESIGN OPENING REMARKS

W Moe *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 2 p (For availability see N74-14271 05-20)

Comments are made concerning the design of combustors Emphasis is placed on the necessity of reducing jet engine pollution without detracting from jet performance Military involvement in aircraft chemical pollution control is also discussed K M M

N74-14298 Office National d'Etudes et de Recherches Aerospatiales Paris (France)

MODELIZATION OF TURBOMACHINE COMBUSTORS FOR POLLUTION STUDIES

Marcel Barrere *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 21 p refs In FRENCH, ENGLISH summary (For availability see N74-14271 05-20)

A survey was made of models currently proposed to calculate the evolution of polluting species in a turbomachine combustor. Efforts were made to improve the models in order to (1) predict the polluting species generation rate by the combustor for various functioning conditions, (2) determine main parameters acting on this polluting rate, and (3) design new optimized combustors generating a minimum of pollutants while retaining the same performance. Author

N74-14299 California Univ., Berkeley Dept of Mechanical Engineering
SMOKE SUPPRESSANT ADDITIVE EFFECTS ON PARTICULATE EMISSIONS FROM GAS TURBINE COMBUSTORS

P J Pagni, L Hughes, and T Novakov *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 11 p refs (For availability see N74-14271 05-20)
(Grants NSF GK-27895, EPA-AP-385)

The effects of manganese based additives on the mass, size distribution, and chemical composition of particulate emissions from gas turbine combustors are described. Experiments show that the additive, 2-methyl cyclo pentadienyl manganese tricarbonyl, can increase mass emissions if used excessively. The additive shifts the emitted particle size distribution toward many more much smaller particles, thereby reducing visibility primarily by reducing the size of the emmited particles. X-ray photoelectron spectroscopy studies have determined that the chemical state of the emitted manganese is manganese monoxide. It is recommended that combustor redesign and collection techniques be employed whenever possible to suppress particulate emissions from aircraft and test facilities. Author

N74-14300 General Electric Co., Cincinnati, Ohio Advanced Combustion and Emissions Control Technology
TECHNOLOGY FOR THE REDUCTION OF AIRCRAFT TURBINE ENGINE EXHAUST EMISSIONS
Donald W Bahr *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 13 p refs (For availability see N74-14271 05-20)

Tests of both production and advanced engines were conducted to determine the emission characteristics of aircraft turbine engines. The results of these engine evaluations are presented. Also presented are the results of exploratory investigations to define and develop design approaches for reducing the carbon monoxide, unburned hydrocarbons, and nitrogen oxides emission levels of high performance annular combustors - with already developed low smoke emission characteristics. In these latter investigations, the emissions level reductions obtainable through the use of advanced primary combustion zone stoichiometry control methods and advanced fuel injection techniques were evaluated. In addition, results are presented on the use of water injection techniques to suppress the formation of nitrogen oxides in combustors. It is concluded that future engines can be developed with significantly lower levels of these gaseous emissions than those of current engines. Author

N74-14301 Cranfield Inst. of Technology (England) School of Mechanical Engineering
A PRELIMINARY STUDY ON THE INFLUENCE OF FUEL STAGING ON NITRIC OXIDE EMISSIONS FROM GAS TURBINE COMBUSTORS
A H Lefebvre and R S Fletcher *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 7 p refs (For availability see N74-14271 05-20)

The results are presented from a preliminary investigation carried out on a tubular aircraft combustor chamber which was perfectly standard apart from an additional fuel injector located just downstream of the primary zone. Measurements of nitric oxide exhaust emissions were carried out over a range of fuel to both primary and secondary zones and the results compared with predictions based on a previously derived mathematical model. Author

N74-14302* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
DESIGN AND EVALUATION OF COMBUSTORS FOR REDUCING AIRCRAFT ENGINE POLLUTION
Robert E Jones and Jack Grobman *In* AGARD Atmospheric Pollution by Aircraft Engine Sep 1973 8 p refs (For availability see N74-14271 05-20)

Various techniques and test results are briefly described and referenced for detail. The effort arises from the increasing concern for the measurement and control of emissions from gas turbine engines. The greater part of this research is focused on reducing the oxides of nitrogen formed during takeoff and cruise in both advanced CTOL, high pressure ratio engines, and advanced supersonic aircraft engines. The experimental approaches taken to reduce oxides of nitrogen emissions include the use of multizone combustors incorporating reduced dwell time, fuel-air premixing, air atomization, fuel prevaporization, water injection, and gaseous fuels. In the experiments conducted to date, some of these techniques were more successful than others in reducing oxides of nitrogen emissions. Tests are being conducted on full-annular combustors at pressures up to 6 atmospheres and on combustor segments at pressures up to 30 atmospheres. Author

N74-14303 Societe Europeene d'Etudes et d'Essais d'Environnement, Buc (France)
MOTORIST POINT OF VIEW ON THE EFFECTS OF LOW BURNING RATES ON POLLUTION [POINT DE VUE DU MOTORISTE SUR LA CONCEPTION DES FOYERS A FAIBLE TAUX DE POLLUTION]
Alain Quillevere, Raymond Briancon, and Jean Decoufiet *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 19 p refs In FRENCH (For availability see N74-14271 05-20)

Possible ways of reducing CO, NO, and hydrocarbons emitted by turbojets are discussed by their designers. It was suggested that high performance annular combustion chambers, reduced air speeds, and modification of existing designs may reduce emissions particularly NO emissions. The use of injector systems to reduce pollution was also examined. Transl by E H W

N74-14304 Air Force Aero Propulsion Lab Wright-Patterson AFB, Ohio
AIRCRAFT GAS TURBINE POLLUTANT LIMITATIONS ORIENTED TOWARD MINIMUM EFFECT ON ENGINE PERFORMANCE
Robert E Henderson and William S Blazowski *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 13 p refs (For availability see N74-14271 05-20)

The proposed Environmental Protection Agency (EPA) regulations for aircraft engine emissions are examined in terms of their impact on the application to military aircraft gas turbine engines. A quantitative assessment of current engine emission levels, design trends and potential emission control techniques is presented. It is concluded that special considerations must be afforded to military aircraft relative to direct application of EPA regulations; however, many future emission-reducing advances will be applicable to military gas turbines. U.S. Air Force goals were established to insure that new engines take advantage of this technology and are in accordance to the greatest degree possible with what EPA requires of commercial aircraft. These goals are in terms of minimum idle combustion inefficiency, maximum allowable oxides of nitrogen (lb/1000 lb fuel), and maximum allowable smoke number. The rationale behind using these parameters and the means by which the numerical limitations were derived are described. Author

N74-14305 Pisa Univ (Italy) Ist di Macchine
PHOTOMETRIC MEASUREMENTS OF EXHAUST SMOKE TRAILS BY JET ENGINES
M Lucchesini and D Dini *In* AGARD Atmospheric Pollution by Aircraft Engines Sep 1973 12 p refs (For availability see N74-14271 05-20)

The purpose of this study is twofold (1) developing a photographic photometry method to measure density and visibility of exhaust smoke trails and (2) obtaining an objective index for the smoke emission on degree by turbojets. Tests show the

P W JT8D9 as being one of the most contaminating jet engines in airline service, giving T values of about 74 percent. Transmission T values were measured in many cases at different distances from the nozzle and for several angles between optical and trail axes. This is done to show dependence of T from the aerodynamic airplane/engine configuration and from the optical path L through the trail. Author

N74-14306 Aerospace Medical Research Labs. Wright-Patterson AFB, Ohio Toxicology Branch

ENVIRONMENTAL TOXICOLOGICAL IMPACT OF AIRCRAFT OPERATIONS

Kenneth C Back *In* AGARD Atmospheric Pollutation by Aircraft Engines Sep 1973 6 p refs (For availability see N74 14271 05-20)

Sources of pollution from aircraft operation include such chemical substances and decomposition products as aviation gasolines, jet fuels, advanced fuels, oils, lubricants, hydraulic fluids, coolants, deicers, and various additives used in these formulations. These may enter the environment as the result of normal mission accomplishment and attendant ground operations, inadvertent malfunctions and spillage and necessary periodic disposal processes. Physiological effects of the more important compounds which are current problems with aircraft pollutants, problems associated with obtaining such biological data, mechanisms necessary to comply with current pollution control directives, and standards which are now functional are also discussed. Author

N74-15349# Advisory Group for Aerospace Research and Development, Paris (France)

TECHNICAL EVALUATION REPORT ON AGARD TECHNICAL MEETING ON ATMOSPHERIC POLLUTION BY AIRCRAFT ENGINES

Paul A. Libby (Calif Univ, La Jolla) Nov 1973 6 p Presented at the Proc. of the Propulsion and Energetics Panel 41st Meeting, Regent's Park, Engl, 9-13 Apr 1973

(AGARD AR 63; AGARD CP 125) Avail NTIS HC $3.00

The environmental problems associated with aircraft operations are discussed. Emphasis is placed on the general problem of air pollution in the neighborhood of airports due to aircraft engine exhaust products. The anticipated benefits from basic combustion research for reducing the pollutants in aircraft engine exhaust are examined. The necessity to determine the amount of pollution caused by aircraft engines as compared with vehicular traffic and adverse meteorological conditions as a basis for cost effective propulsion system modifications is stressed. Author

21 NAVIGATION

Includes guidance, autopilots, star and planet tracking, inertial platforms, and air traffic control. For related information see also 07 Communications

N72-22621# Advisory Group for Aerospace Research and Development, Paris (France)
GUIDANCE AND CONTROL DISPLAYS
Feb 1972 237 p refs Presented at 13th Meeting of Guidance and Control Panel of AGARD, Paris, 19-21 Oct 1971
(AGARD-CP-96) Avail NTIS

Conference papers are presented on guidance and control display design for aerospace vehicles. The particular areas of investigation are visual criteria, workload criteria, validation of design criteria, VTOL aircraft displays, displays for specific applications, new technology, and testing and evaluation of displays. For individual titles, see N72-22622 through N72-22644

N72-22622# Air Force Flight Dynamics Lab, Wright-Patterson AFB, Ohio Flight Deck Development Branch
THE STATUS OF HUMAN PERCEPTUAL CHARACTERISTIC DATA FOR ELECTRONIC FLIGHT DISPLAY DESIGN
Keith I. Burnett *In* AGARD Guidance and Control Displays Feb 1972 10 p refs (See N72-22621 13-21)
Avail NTIS

The human factors literature was searched and analyzed for human perceptual characteristic data relating to the design of individual electronic flight displays. Some of the more interesting data obtained are summarized and include flicker, visual acuity, display resolution, luminance, alphanumeric legibility, scale legibility, information coding, display size, and the effect of environmental variables on these quantities. Wherever possible the data are analyzed and presented so as to point out significant variables and data trends not specifically discussed in the original works Author

N72-22623# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany) Inst fuer Flugfuehrung
A LIMITED STUDY OF THE TRADE OFF BETWEEN LUMINANCE AND COLOR CODING IN ELECTRONIC AIRCRAFT DISPLAYS
Ralf Beyer *In* AGARD Guidance and Control Displays Feb 1972 9 p refs (See N72-22621 13-21)
Avail NTIS

The effectiveness of luminance and color coding are compared as means for coding display elements in electronic displays. First a review of some past investigations is given. Next some experiments are described which contain an immediate-response task, a single-axis tracking experiment with discontinuous secondary task, tachistoscopic experiments, and the exploration of subjective judgements on different types of color coding in an experimental electronic display. In these experiments the only variable is the type of coding (luminance or color) used for the display elements and the various responses obtained are discussed Author

N72-22624# Human Engineering Labs, Aberdeen Proving Ground, Md
WHAT COLOR DISPLAY ELEMENT
John A Barnes *In* AGARD Guidance and Control Displays Feb 1972 11 p refs (See N72-22621 13-21)
Avail NTIS

The results are presented of research directed toward determining the best possible colors to use for the elements of a multicolored aircraft display to insure a minimum number of instrument reading errors. A survey of the American manufacturers of multicolored mechanical aircraft displays provided a list of nine colors generally used as background colors and a like number of generally used pointer colors. An integrally illuminated test instrument was built which had the capability of presenting to a test subject any of these background and pointer colors in combination. The lighting of the test instrument was controlled at either of two illumination levels for each background color and was available, with this control, as a red lighting system or as a blue-white lighting system. These results provide the instrument manufacturers with twenty pointer and background combinations which can be expected to produce less than a one percent instrument scale reading error, regardless of the lighting system used and at illumination levels as low as 01 foot Lamberts
Author

N72-22625# Litton Systems, Inc, Van Nuys, Calif Data Systems Div
THE INTEGRATED COCKPIT PROCEDURE FOR IDENTIFYING CONTROL AND DISPLAY REQUIREMENTS OF AIRCRAFT IN ADVANCED TIME PERIODS
John V Murphy and Bernard S Gurman (ECOM, Fort Monmouth N J) *In* AGARD Guidance and Control Displays Feb 1972 7 p refs (See N72-22621 13-21)
Avail NTIS

An adaptation of the integrated cockpit research procedure was used to define control and display requirements for the next generation utility transport helicopter under consideration by the US Army. A control and display requirements analysis was conducted based upon the derivation of specific functions necessary for accomplishing four specified missions. Control/display mechanization was derived from specific mission functions. A time-based load analysis was performed utilizing computer processing techniques to make task adjustments in real time and provide a printout of how the tasks in each mission segment could be adjusted to meet the mission requirement. The technique also provided an analysis of contingency situations and denoted overload conditions that occurred. The hard copy mock-up was a full-scale cockpit shell in which the alternative mission control/display configurations could be illustrated. The mock-up contained realistic flight controls and audiovisual projector units that simulated vertical and horizontal situation display formats Author

N72-22626# Honeywell, Minneapolis, Minn Systems and Research Div
DESIGN IMPLICATIONS OF A BETTER VIEW OF THE MULTICHANNEL CAPACITY OF A PILOT
O H Lindquist *In* AGARD Guidance and Control Displays Feb 1972 6 p refs (See N72-22621 13-21)
Avail NTIS

A major result of a recently completed study is the prediction and measurement of multichannel pilot performance, which significantly increases his information handling capability beyond that predicted by today's techniques. Current techniques of predicting man/machine interactions were shown to be in error by an order of magnitude in some measurements related to human channel capacity. The results of this experimental work are presented and system design implications for pilot capability and limitations are discussed Author

N72-22627*# Systems Technology Inc, Hawthorne, Calif
SYSTEMATIC MANUAL CONTROL DISPLAY DESIGN
W F Clement, D T McRuer, and R H Klein *In* AGARD Guidance and Control Displays Feb 1972 10 p refs Sponsored in part by NASA and JANAIR (See N72-22621 13-21)
(NASA-CR-126256) Avail NTIS CSCL 01D

The principles are outlined of guidance and control display design based on interactions with human psychomotor activity. The inspirations for eye movement studies in flight control and monitoring tasks and the relationship of eye scanning phenomena to pilot describing functions and remnant are summarized. Several measures of pilot workload in control tasks are discussed

Excess control capacity, in particular has great promise in quantifying a practical definition of workload. It is a major workload connector with pilot opinion rating and whole-task effective time delay. Further connections with lead equalization, scanning workload, physiological measures of neuromuscular tension, and the effects of additional modalities on visual workload are illustrated. Author

N72-22628# Forschungsinstitut fuer Anthropotechnik, Meckenheim (West Germany).
A SYMBOL GENERATOR FOR THE ANTHROPOTECHNICAL EVALUATION OF INTEGRATED DISPLAYS
K.-F. Kraiss *In* AGARD Guidance and Control Displays Feb. 1972 7 p refs (See N72-22621 13-21)
Avail: NTIS

A freely programmable low-cost high-quality character-generator is described, which uses a hybrid principle of generation. The writing is performed by a combined stroke writing and Lissajous procedure that results in an increased display quality. The binary information needed is stored in a core memory. The applied circuit design enables the writing of a continuous curve, which may be arbitrarily composed of dots and lines. The presentation of alphanumeric symbols and complex geometric figures is performed using a 15 by 15 dot matrix for construction. Color coding capability is provided by multilayer CRT. Since programming of the displayed picture is done by simple statements on punched tape, the generator becomes an excellent and flexible experimental device for the human engineering evaluation of electronic displays. An example for application is cited. Author

N72-22629# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
A METHOD OF MAN-DISPLAY/CONTROL SYSTEM EVALUATION
Ruediger Seifert (British Aircraft Corp., Preston, England), Alan F. Daniels (British Aircraft Corp., Preston, England), and Klaus Schmidt *In* AGARD Guidance and Control Displays Feb. 1972 9 p refs (See N72-22621 13-21)
Avail: NTIS

A method of evaluating the design and assessing the layout of an aircraft cockpit is described. Factors significantly affecting the design, such as scenario, operational, and equipment requirements are introduced and a description of the rig facility provided. The use of the Cooper Harper rating system, semantic differentials, and guided interviews in the analysis of subject performance and opinion is described. It is concluded that complex man-display/control systems can only be optimized by the adoption of a comprehensive approach to experimental studies. Author

N72-22630*# Massachusetts Inst. of Tech., Cambridge. Man-Vehicle Lab.
INTEGRATED DISPLAY PRINCIPLES AND SOME APPLICATIONS TO V/STOL AIRCRAFT
Laurence R. Young *In* AGARD Guidance and Control Displays Feb. 1972 7 p refs (See N72-22621 13-21)
(Grant NGR 22-009-025)
(NASA-CR-126153) Avail: NTIS CSCL 01D

Design guidelines for pictorial integrated displays are presented, and include the display format and scaling based on expected flight path control requirements. The guidelines are illustrated by the bottom window predictor VTOL display, a perspective glide-slope contact analog V/STOL display, and an airborne air traffic situation display. Author

N72-22631# Vereinigte Flugtechnische Werke-Fokker G.m.b.H., Bremen (West Germany).
EVALUATION OF AN INTEGRATED FLIGHT DISPLAY FOR THE MANUAL IFR-LANDING OF VTOL AIRCRAFT
H. J. Kornstaedt and J. Pleinigstorf *In* AGARD Guidance and Control Displays Feb. 1972 6 p refs (See N72-22621 13-21)
Avail: NTIS

An integrated flight display for the hovering phase of a VTOL landing was developed. The presentation of information to the pilot is evaluated in simulation by three criteria: landing performance, pilot rating, and measurement of the pilot's mental workload. Adaptation of the display dynamics and the desired landing-profile lead to higher level of performance at a decreased workload. Author

N72-22632# Ministry of Defence, London (England).
V/STOL DISPLAYS FOR APPROACH AND LANDING
David J. Walters and Ralf Beyer (DFVLR) *In* AGARD Guidance and Control Displays Feb. 1972 10 p (See N72-22621 13-21)
Avail: NTIS

The information requirements of a pilot carrying out a V/STOL approach and landing under adverse weather conditions are described, and solutions that were tried out experimentally are analyzed. Among the tentative conclusions are the following: (1) The amount of information needed for V/STOL displays and the independent motion in various axes pose problems in combining and integrating the information channels. It seems possible to combine both a horizontal and a vertical display in one format, the most difficult element to incorporate is the height information. (2) Most current displays were empirically designed without much regard for underlying principles. (3) An optimum cost effective mix of displays and controls appears to involve automatics for inner loop stabilization and displays with manual control for monitoring outer loop control. (4) Techniques of engineering displays for conventional flight appear adequate for V/STOL. Author

N72-22633# Ferranti, Ltd., Edinburgh (Scotland).
A NAVIGATION COMPUTER AND DISPLAY UNIT FOR HARRIER
Thomas S. Briggs *In* AGARD Guidance and Control Displays Feb. 1972 14 p refs (See N72-22621 13-21)
Avail: NTIS

The navigation display and computer for the Harrier strike aircraft is a compact, comprehensive, and self-contained navigation instrument. It contains a pictorial presentation of the navigational situation in the form of a projected moving map, together with the means of storing and selecting the coordinates of a number of destinations or fix points. A variety of numerical information such as latitude and longitude, time-to-go, and ground speed can be selected and displayed optically superimposed on the projected moving map. The display and computer contains all the facilities required for the management of the navigation aspects of the mission profile in one centralized area of the cockpit instrument panel. Particular attention is given to overcoming the viewing problems associated with the use of projected moving map displays in conditions of high ambient lighting, and to providing navigational control and operational facilities which are easy to use in practice. Author

N72-22634# Anacapa Sciences, Inc., Santa Barbara, Calif.
CONTEMPORARY MAP DISPLAYS
James J. McGrath *In* AGARD Guidance and Control Displays Feb. 1972 16 p refs (See N72-22621 13-21)
Avail: NTIS

A general review of developments and capabilities in airborne map display systems is presented. A brief overview of the complicated history of research, development, and operational use is presented first, and then the development of each of four basic types of map displays is traced from its origin to its present status. The four types are: direct-view map displays, projected map displays, combined map/CRT displays, and electronically generated map displays. The main advantages and limitations of each type are noted, and the various ways in which the basic design concepts have been implemented are described. A number of design issues and operational problems of current importance are identified and briefly discussed. Author

N72-22635# Smiths Industries Ltd., Bishops Cleeve (England) Aviation Div.
THE IMPACT OF ADVANCING TECHNOLOGY ON THE EVOLUTION OF ELECTRONIC HEAD-UP DISPLAY SYSTEMS
John H. Smith *In* AGARD Guidance and Control Displays Feb. 1972 10 p (See N72-22621 13-21)
Avail: NTIS

The history of electronic head-up display system as applied to military aircraft is outlined. The various major developments demanded by successive avionic system requirements, and the way in which advancing technology, mainly in the area of components, allows these increasingly stringent requirements to be implemented are discussed. The main emphasis is on the engineering and hardware aspects, and systems fitted to current production aircraft such as the Harrier are discussed. Reference is also made to the most recent developments where computation for weapon delivery, or other purposes, can be provided as an integral facility within the electronics unit. Author

N72-22636# Elliott Flight Automation, Ltd., Rochester (England) Airport Works.
SOME ENGINEERING AND OPERATIONAL FACTORS OF MULTISENSOR DISPLAYS
P. A. Hearne and D. W. Hussey *In* AGARD Guidance and Control Displays Feb. 1972 14 p (See N72-22621 13-21)
Avail: NTIS

The operational advantages of presenting a range of complementary data to the aircrew from which they can make improved deductive judgements is briefly discussed and some operational requirements are outlined. The engineering solutions are shown to favor a raster based display which can accommodate both computed and sensor data in the same format. Methods of display computation and scan conversion associated with this raster technique are described and typical displays produced by these methods are illustrated. Author

N72-22637# Compagnie Generale de Telegraphie sans Fil, Paris (France). Div. des Equipments Avioniques et Spatiaux.
INTEGRAL COMMAND AND CONTROL SYSTEM FOR AIRCRAFT [SYSTEME INTEGRE DE CONTROLE ET DE COMMANDE DES AVIONS]
Marie-Jacques Jullien *In* AGARD Guidance and Control Displays Feb. 1972 12 p In FRENCH (See N72-22621 13-21)
Avail: NTIS

Operating characteristics and techniques are presented for an aircraft integrated command and control system. The system is designed to ease the primary tasks of pilots in the coming years, tasks which have become increasingly difficult due to machine complexity and steadily growing air traffic density.
Transl. by K.P.D.

N72-22638# Air Force Materials Lab., Wright-Patterson AFB, Ohio.
MATERIALS AND TECHNOLOGY FOR NEW INFORMATION DISPLAYS
Patrick M. Hemenger *In* AGARD Guidance and Control Displays Feb. 1972 9 p refs (See N72-22621 13-21)
Avail: NTIS

The current status of electroluminescent materials and devices is reviewed. The limitations of the presently important materials GaP (gallium phosphide) and GaAsP (gallium arsenide phosphide) are discussed, followed by a survey of candidate materials for future display systems. In particular, the potential of groups 2-6 semiconductors is presented along with some recent experimental results. Author

N72-22639# Farrand Optical Co., Inc., Valhalla, N.Y.
A MULTIPURPOSE WIDE FIELD, THREE DIMENSIONAL HEAD UP DISPLAY FOR AIRCRAFT
Joseph A. LaRussa *In* AGARD Guidance and Control Displays Feb. 1972 10 p ref (See N72-22621 13-21)
Avail: NTIS

A system useful to pilots for approach and landing and for navigation is described. Attitude, airspeed, altitude, and spatial location as derived both from analog display which is projected through the windscreen and superimposed on the real world view. The display is a three-dimensional roadway in the sky, down which the aircraft can be flown either for navigation or to a touchdown on the runway. The roadway may also be used to define a holding pattern or even a complete route from takeoff to touchdown. The three-dimensional analog display reduces pilot interpretation time and thereby provides for better aircraft control. Author

N72-22640# Motorola, Inc., Scottsdale, Ariz.
A TRUE 3D OR FLAT 2D DISPLAY
Jordon D. Lewis (Battelle Develop. Corp.) and George P. Walling *In* AGARD Guidance and Control Displays Feb. 1972 6 p refs (See N72-22621 13-21)
Avail: NTIS

A display principle is described for a true 3-D display or a multicolor, solid state, flat panel display. The display volume or surface is a transparent material in which an isolated moving spot is created. Arbitrary 2-D or 3-D figures are generated by rapidly moving the spot in two or three dimensions refreshed at a sufficient rate to eliminate flicker. Data may be entered from conventional sources into the refresh memory, and manual interaction via a movable cursor is possible. The advantages of presenting 3-D information in a true 3-D format are discussed, and applications to display clutter reduction are described. The requirement for a compact, flat panel cockpit display is directly addressed. Author

N72-22641# Singer-Kearfott, Little Falls, N.J.
SPACE TECHNOLOGY APPLICATIONS TO GUIDANCE AND CONTROL DISPLAYS
Joseph Koprowski *In* AGARD Guidance and Control Displays Feb. 1972 11 p refs (See N72-22621 13-21)
Avail: NTIS

Spacecraft displays with their need for small size, low weight, low power consumption, and high reliability have required all solid state digital displays using electroluminescent or light-emitting diode illumination techniques. Advanced integrated circuit electronics, novel mechanical packaging techniques, and high-reliability assurance programs are used in these displays. These technologies, and several existing and other under-development aerospace displays and control units utilizing these technologies are reviewed. Author

N72-22642# Anacapa Sciences, Inc., Santa Barbara, Calif.
UTILITY OF THE VERTICAL CONTACT ANALOG DISPLAY FOR CARRIER LANDINGS: A DIAGNOSTIC EVALUATION
Kenneth D. Cross and Frank R. Cavallero (Naval Missile Center) *In* AGARD Guidance and Control Displays Feb. 1972 11 p refs (See N72-22621 13-21)
(ONR Proj. 0-0077; ONR Proj. 0-0078; ONR Proj. 0-0079)
Avail: NTIS

The accuracy of the pictorial vertical situation display generated by a digital computer was evaluated. Position and attitude errors were measured under each of five experimental conditions, a full-scale simulated carrier landing task and four part-tasks. The part-tasks were designed to assess the degree to which display resolution, temporal loading, and control complexity contribute to total system error. All three attitude parameters were controlled with a high degree of accuracy under all conditions. Control of vertical and lateral position in the full-scale simulation condition was accomplished with about the same accuracy and precision as that reported for actual (day) carrier landings in F-4 aircraft. The part-task data revealed that the largest contributor to lateral error was control complexity, whereas display resolution and temporal loading were found to be large and roughly equivalent contributors to vertical error.
Author

N72-22643# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Flight Deck Development Branch

RATE OF CLOSURE AS A PERFORMANCE AS A PERFORMANCE MONITORING PARAMETER

Eldon M Bobbett and Kenneth R Woodruff (Sys Res Labs, Inc., Dayton, Ohio) *In* AGARD Guidance and Control Displays Feb. 1972 11 p refs (See N72-22621 13-21)

Avail NTIS

Surveys on approach and landing accidents revealed the need for rate-of-closure information. Presenting the information and subjecting it to operational criticism were accomplished with a simulation evaluation of a modified Attitude Director Indicator (ADI) incorporating the rate-of-closure information, a two phase flight test evaluation of the same indicator, and a simulation evaluation of a cathode ray tube ADI with rate-of-closure information presented similarly to how it is presented in the electromechanical ADI. The results are explicit in that rate-of-closure information is a requirement in the approach and landing modes and does a good job as a performance monitoring parameter. Author

N72-22644# Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio. Flight Deck Development Branch

THE ELECTROLUMINESCENT LIGHTING RESEARCH PROGRAM

David L Turney and Leroy Addis (Lear Siegler, Inc., Grand Rapids, Mich.) *In* AGARD Guidance and Control Displays Feb 1972 11 p refs (See N72-22621 13-21)

Avail NTIS

Experiments flown in a T-39 aircraft by experienced pilots were designed to simulate different types of operational flights by progressively increasing the external visual task loading on the pilot. Both objective measurements and pilot opinion data were obtained on display illumination under external ambient illumination ranging from twilight to night no-moon conditions. Photometric data showed that the pilot's display lighting requirements were influenced by the outside illumination only when this illumination exceeded 001 foot candles. When the night illumination fell below this level, display illumination was primarily influenced by the pilot's preflight dark adaptation; the type of information required for successful mission completion, the priority the pilot placed on the information available, and the effects of cockpit lighting on display legibility. Author

N72-27681# Advisory Group for Aerospace Research and Development, Paris (France)

GUIDANCE AND CONTROL OF TACTICAL MISSILES

May 1972 116 p refs

(AGARD-LS-52) Avail NTIS HC $8.00

The control and guidance of tactical missiles with emphasis on cost, reliability, and performance are discussed. The utility of modern analysis and evaluation tools and techniques associated with the several commonly used control and guidance concepts are also examined. For individual titles, see N72-27682 through N72-27693

N72-27682 Martin Marietta Corp., Orlando, Fla

GENERAL CONSIDERATIONS IN GUIDANCE AND CONTROL TECHNOLOGY

Philip C Gregory *In* AGARD Guidance and Control of Tactical Missiles May 1972 14 p (For availability see N72-27681 18-21)

A particular set of mission requirements for an air to air missile and an automated design process to synthesize these requirements into the preliminary design of a missile and guidance system are described. This process makes use of the CAMS (Computer Aided Missile Synthesis) digital computer program which was developed to (1) synthesize missile configurations including the guidance, controls, secondary power, warhead and propulsion subsystems, (2) furnish resulting flight performance including trajectories and miss distance, and (3) estimate unit costs Author

N72-27683 Boeing Co., Seattle, Wash. Aerospace Group

DEVELOPMENT OF CONTROL SYSTEM REQUIREMENTS

Robert Goodstein *In* AGARD Guidance and Control of Tactical Missiles May 1972 7 p (For availability see N72-27681 18-21)

The development of control system requirements for tactical missiles is discussed. The timing of control system requirements and the manner in which requirements are incorporated are described. Three examples are presented to show the variety of issues, candidate solutions, and selections of control systems to meet requirements. The type of weapon system requirement, process of analysis, and reasoning on concept selection are included to show application to advanced missile design. Author

N72-27684 McDonnell-Douglas Astronautics Co., Huntington Beach, Calif

ADJOINT SOLUTIONS TO INTERCEPT GUIDANCE

D L Pitman *In* AGARD Guidance and Control of Tactical Missiles May 1972 5 p (For availability see N72-27681 18-21)

The adjoint equations yielding the error sensitivities of a linear system are explained. The Laplace transforms representing the solutions of the adjoint equations of a linear interceptor guidance system are developed. The solutions for an interceptor, represented by a first order lag and utilizing proportional navigation, are derived. Author

N72-27685 McDonnell-Douglas Astronautics Co., Huntington Beach, Calif

OPTIMIZATION

D L Pitman *In* AGARD Guidance and Control of Tactical Missiles May 1972 4 p (For availability see N72-27681 18-21)

The procedure for optimizing a linear system against a quadratic cost function is developed by the method of completing a square. The optimal intercept guidance law against a nonmaneuvering target when the cost is energy lost to drag is shown to be proportional navigation with a gain of 3 Author

N72-27686 McDonnell-Douglas Astronautics Co., Huntington Beach, Calif

KALMAN FILTER

D L Pitman *In* AGARD Guidance and Control of Tactical Missiles May 1972 6 p (For availability see N72-27681 18-21)

The Kalman filter is developed as a rational application of Gauss method of least mean square error summing, which adds together independent measurements and estimates proportionally to the inverse of the variances of expected errors. The discrete measurement summer is developed into the continuous filter by shortening the time between measurements Author

N72-27687 Royal Aircraft Establishment, Farnborough (England)

NUMERICAL ANALYSIS AND SIMULATION EVOLUTION

E Heap *In* AGARD Guidance and Control of Tactical Missiles May 1972 7 p (For availability see N72-27681 18-21)

A review is given of the quantitative advantages and disadvantages of digital and analogue computer techniques for the simulation of missile guidance and control, and a methodology of using hybrid simulation is developed. It is shown how a hybrid computer can be used to aid the choice of an acceptable missile system within a wide spectrum of complexity particularly when many non linear factors and statistical aspects are involved. Using this facility mathematical modelling not only helps specific projects in their R & D phases, but it can contribute to management decisions in feasibility studies, in the choice of missile instrument combinations and in the specification of their desired standard of performance. It can also safeguard against complex systems being over designed to the detriment of their cost Author

N72-27688 Martin Marietta Corp. Orlando, Fla.
LABORATORY TECHNIQUES AND EVALUATION METHODOLOGY
Philip C. Gregory *In* AGARD Guidance and Control of Tactical Missiles May 1972 10 p (For availability see N72-27681 18-21)

The characteristics of typical electro-optical terminal guidance subsystems including area correlator and gated trackers are furnished to define those parameters (aim and lock-on capability, tracking accuracy, tracking bandwidth, aspect angle capability, sensitivity to target and light level variations, acquisition envelope, and range closure effects) which are important to the system user. A laboratory designed to repeatedly measure these properties is described. Typical area correlator tracker characteristics are furnished and a run schedule defined to evaluate the performance parameters described. An economic analysis is presented to illustrate the potential cost savings over flight test. Author

N72-27689 Boeing Co., Seattle, Wash. Aerospace Group.
GUIDANCE LAW APPLICABILITY FOR MISSILE CLOSING
Robert Goodstein *In* AGARD Guidance and Control of Tactical Missiles May 1972 6 p (For availability see N72-27681 18-21)

Guidance law general types to produce missile steering signals from sensed target information leading to suitably close miss distances are discussed. Miss distance variations for the different guidance laws are displayed for an air target intercept as target and missile characteristics are changed. A general comparison of guidance law applicability is presented for air and surface targets. Author

N72-27690 Aeronautical Systems Div., Wright-Patterson AFB, Ohio.
SELF-CONTAINED GUIDANCE TECHNOLOGY
R. W. Acus, Jr. *In* AGARD Guidance and Control of Tactical Missiles May 1972 18 p refs (For availability see N72-27681 18-21)

Inertial technology for a self-contained guidance capability applicable to tactical air-to-ground missiles is discussed. The basic inertial system, which consists of accelerometers, gyros and a computer, is immune to outside interference, and therefore ideally suited to military applications in a hostile environment. Inertial technology has progressed to a point where equipment size and cost are within reason for use with the tactical missile. The basic principles and limitations of inertial guidance, including theory of operation, and physical and analytic coordinate system stabilization are presented. Sources of error and the propagation of these errors are described. Various methods of alignment, and system mechanization are considered. The state of the art, and the research and development process for inertial systems is discussed. Factors influencing the research and development process are identified along with the relationship between inertial system reliability and cost. Author

N72-27691 Aeronautical Systems Div., Wright-Patterson AFB, Ohio.
APPLICATION OF INERTIAL TECHNOLOGY TO A-G MISSILES
R. W. Acus, Jr. *In* AGARD Guidance and Control of Tactical Missiles May 1972 11 p refs (For availability see N72-27681 18-21)

Inertial technology for airborne, stand-off tactical weapon systems both as a midcourse guidance system and when used in conjunction with a terminal guidance sensor is discussed. The capabilities of pure inertial guidance are examined as the midcourse guidance system for a stand-off missile. The relationships between enemy defenses, aircraft capability and missile performance are used to define a hypothetical mission and a set of guidance system requirements. Error magnitudes are selected and missile positional error is determined as a function of range. The stand-off range of this particular weapon system is limited by the performance of the midcourse guidance system. Various methods of improving midcourse guidance performance are explored. The advantages and limitations of an aided inertial system are reviewed with emphasis on retaining the advantages of the self-contained system. Author

N72-27692 Royal Aircraft Establishment, Farnborough (England).
METHODOLOGY OF RESEARCH INTO COMMAND-LINE-OF-SIGHT AND HOMING GUIDANCE
E. Heap *In* AGARD Guidance and Control of Tactical Missiles May 1972 9 p (For availability see N72-27681 18-21)

Research of command-to-line-of-sight (CLOS) guidance and semi-active homing missile systems is presented. It discusses the kinematics of various guidance laws from CLOS to pursuit courses and proportional navigation from a fundamental point of view. The interaction between the guidance requirements and the missile system is covered and it is shown that the autopilot and sensor effects need to be considered in hybrid computer simulations. The implications on computer requirements for optimum filtering are also discussed. Author

N72-27693 Raytheon Co., Bedford, Mass. Missile Systems Div.
PULSE DOPPLER MISSILE GUIDANCE: REPRESENTATIVE PARAMETERS AND ASSOCIATED FIRE CONTROL CONSIDERATIONS
Henry Zuerndorfer, Howard Lynn, and Gordon Kettering *In* AGARD Guidance and Control of Tactical Missiles May 1972 17 p ref (For availability see N72-27681 18-21)

The principal problems and solution options available for all weather attack of small tactical targets are discussed. The requirement for all-weather operation against relatively small and possibly mobile targets dictates the use of microwave guidance sensors. The problems of detection and the tracking and fire control considerations associated with the attack of three generic types of tactical targets are presented. The characteristics of the available sensors are described and the applications for various situations are examined. Author

N73-20684# Advisory Group for Aerospace Research and Development, Paris (France).
INERTIAL NAVIGATION COMPONENTS AND SYSTEM
Feb. 1973 402 p refs In ENGLISH; partly in FRENCH. Presented at the 15th Meeting of the Guidance and Control Panel of AGARD, Florence, 2-5 Oct. 1972
(AGARD-CP-116) Avail: NTIS HC $22.25

The proceedings of a conference on inertial navigation components and systems are presented. The objective of the meeting was to provide current information of inertial navigation developments and to discuss applications and test results. Emphasis was placed on concepts and techniques which show the trade-offs dealing with cost versus performance. The subjects discussed include: (1) strapped down inertial guidance systems, (2) inertial navigation systems for the space shuttle, (3) materials for the inertial navigation systems, (4) gyro stabilized platform applications, (5) inertial system for missile midcourse guidance, and (6) fault isolation and maintenance concepts for inertial navigation systems. For individual titles, see N73-20685 through N73-20717.

N73-20686 Officine Galileo S.p.A., Florence (Italy).
STRAPPED DOWN INERTIAL GUIDANCE SYSTEM STUDY
R. Baldassini Fontana *In* AGARD Inertial Navigation Components and Systems Feb. 1973 42 p refs (For availability see N73-20684 11-21)

The sources and magnitudes of errors occurring in a strapped down environment are discussed. The functions of the accelerometers and gyroscopes in a strapped down system are described. The parameters which must be investigated and defined to evaluate the performance of a stabilized platform are tabulated. The requirements of inertial sensors for maintaining vehicle attitude, velocity, and position are examined. Mathematical models for determining the errors produced by various parameters which affect the inertial system are developed. Diagrams of typical strapdown systems are included. P.N.F.

N73-20686 Massachusetts Inst. of Tech., Cambridge. Charles Stark Draper Lab.
SUMMARY OF NEW DEVELOPMENTS AT THE DRAPER LABORATORY
Robert A. Duffy *In* AGARD Inertial Navigation Components

and Systems Feb 1973 5 p (For availability see N73-20684 11-21)

Research projects involving the development of inertial guidance systems and components are discussed. The application of inertial guidance to tactical and strategic missile systems is analyzed. The efforts of the laboratory in support of the Apollo project are examined. Fault tolerant design concepts in digital computer construction are advocated as a means of achieving improved reliability. Systems for stabilizing Orbital Astronomical Observatory satellites are reported. Specific systems for lunar exploration, commercial air transportation, oceanography, flight control, and biomedical experiments are briefly discussed. P.N.F.

N73-20687* Massachusetts Inst. of Tech., Cambridge. Charles Stark Draper Lab.

FAILURE MANAGEMENT OF MULTIPLE GIMBAL INERTIAL SYSTEMS FOR SPACE SHUTTLE

David W. Dove and Richard A. McKern *In* AGARD Inertial Navigation Components and Systems Feb. 1973 14 p refs Sponsored by NASA (For availability see N73-20684 11-21) CSCL 17G

A failure detection and isolation technique for use with four gimbaled inertial measurement units (IMU) is presented. By using simulated boost and entry shuttle trajectories with specific gimbaled IMU models, failure detection thresholds are developed based on red-line life dependent requirements and warning thresholds within the red-line thresholds based on expected worst case IMU performance. Using these trajectories, established trajectory threshold, and multiple IMU models, various failure detection and isolation techniques are evaluated for application in both powered and unpowered flight phases. The adequacy of the systems for both attitude and velocity detection methods is evaluated and recommendations for space shuttle applications are made. Author

N73-20688 Massachusetts Inst. of Tech., Cambridge. Charles Stark Draper Lab.

STRAPDOWN INERTIAL GYROSCOPE

Michele S. Sapuppo *In* AGARD Inertial Navigation Components and Systems Feb. 1973 10 p refs (For availability see N73-20684 11-21)

A miniature single-degree-of-freedom gyroscope has been developed for the application to a strapdown inertial guidance system. This development is based on many years of experience with the design and development of high-performance pendulous integrating gyroscopic accelerometers (PIGA). By utilizing basic design principles of the gyroscopic element contained in the PIGA, which by nature of the PIGA operation presents a slew environment to the gyroscopic element, a strapdown gyroscope evolves which operates and performs exceptionally well under high linear accelerations and high slew rates. This paper describes a strapdown gyroscope that is less than 1-1/2 inches in diameter by 2 inches in length and weighing under 1/2 pound. The angular momentum is only 8.5 X 1,000 dyne cm sec. which gives it several natural benefits of small size, low power consumption, high reliability, and reasonable cost. To achieve high performance with low angular momentum, low uncertainty torques are required about the output axis of the gyroscope. The design of this strapdown gyroscope involved the systematic identification of each error source coupled with the introduction of subcomponent design principles to reduce these error magnitudes and therefore minimize the consequential sources of uncertainty torque. Author

N73-20689 Massachusetts Inst. of Tech., Cambridge. Charles Stark Draper Lab.

INERTIAL-GYRO TESTING FOR RELIABILITY

Albert P. Freeman *In* AGARD Inertial Navigation Components and Systems Feb. 1973 10 p (For availability see N73-20684 11-21)

Methods for conducting reliability tests of gyroscopes used with inertial platforms. The types of tests required are defined as (1) acceptance tests to determine if the gyroscope can meet performance requirements and (2) reliability and/or design verification tests. The acceptance tests are identified to show the parameters which are measured. The design verification tests are concerned with environmental tests, reliability analyses, and engineering evaluation. A typical reliability test specification is included. P.N.F.

N73-20690 Litton Systems, Inc., Woodland Hills, Calif.

P-4, A LOW-COST IMU RESULTING FROM OPTIMUM SIZE DESIGN

John H. Tamura and John M. Peterson *In* AGARD Inertial Navigation Components and Systems Feb. 1973 9 p (For availability see N73-20684 11-21)

The P-4 Inertial Measurement Unit development program was undertaken to achieve a low-cost IMU with navigational accuracy performance resulting from optimum size design of inertial instruments and platform. This approach placed a heavy emphasis on simplification and reduction in the number and complexity of individual parts. The cost-size tradeoff studies which were conducted for the inertial components, gimbal set, and system during the design phase are presented and discussed. The result of the development program is an inertial platform of 7.3 inches in diameter and 3.15 inches in length, weighing 1.9 pounds and requiring 25 watts of power. The resulting Inertial Measurement Unit is contained in a single package 3.5 inches by 3.25 inches by 7.25 inches, weighing 6 pounds. Author

N73-20691 Societe d'Applications Generales d'Electricite et de Mecanique, Paris (France)

METHOD OF MEASURING THE INERTIAL QUALITIES OF A QUASI-SPHERICAL ROTOR [METHODE DE MESURE DES QUALITES INERTIELLES D'UN ROTOR QUASI SPHERIQUE]

L. Camberlein, A. Ceval, and J. C. Silvestre *In* AGARD Inertial Navigation Components and Systems Feb. 1973 9 p refs In FRENCH (For availability see N73-20684 11-21)

A method for measuring inertia that is applicable to spherical gyroscope rotors with electric suspension is analyzed. The method permits the principle axis of inertia relative to the center of mass to be determined and allows the relative differences of inertial moments to be measured. Transl. by E.H.W.

N73-20692 Queen Mary Coll., London (England). Dept. of Materials.

MICROPLASTICITY IN MATERIALS FOR INERTIAL NAVIGATION SYSTEMS

William Bonfield *In* AGARD Inertial Navigation Components and Systems Feb. 1973 6 p refs (For availability see N73-20684 11-21)

The determination of the friction stress, the microscopic yield stress (the stress to produce a plastic strain of 2 x 10.000006) and the rate of strain hardening in the microstrain region is described. An evaluation of the influence of some metallurgical variables on these parameters is presented, in which particular reference is made to the characteristics of beryllium, aluminum and a copper-beryllium age hardening alloy. The interpretation of the microstrain results is discussed from two standpoints, first, the development of a general understanding of microplasticity, and, second, the application of such concepts to inertial navigation components. Author

N73-20693 Army Electronics Command, Fort Monmouth, N.J. Avionics Lab.

RAPID INITIALIZATION OF INERTIAL NAVIGATION SYSTEMS THROUGH PARAMETER ESTIMATION

Joseph A. Dasaro *In* AGARD Inertial Navigation Components and Systems Feb. 1973 11 p refs (For availability see N73-20684 11-21)

The problem of rapid initialization of an inertial navigation system using an azimuth wander mechanization is treated in detail. An error model is developed which contains all significant cross coupling terms and inertial component random drifts. Determination of the initial azimuth wander angle is then identified as a parameter estimation problem where the parameter can assume any of a continuum of values (from 0 to 2 pi). Two methods of solving parameter estimation problems currently in

the literature are discussed. One of the methods is then extended to permit time optimal estimation of the initial azimuth angle. The platform controller is developed and the overall system described. Results of a computer simulation are presented. Author

N73-20694 Teldix Luftfahrt-Ausruestungs G.m.b.H., Heidelberg (West Germany)
INVESTIGATIONS ON THE OPTIMIZATION OF AIDED INERTIAL NAVIGATION SYSTEMS
Rainer S. Sindlinger *In* AGARD Inertial Navigation Components and Systems Feb. 1973 16 p refs (For availability see N73-20684 11-21)

The stringent performance requirements for modern, self-contained aircraft navigation systems can only be met by integrated systems combining several independent navigation sensors, like inertial measurement unit, Doppler radar, and radio position fixing devices (e.g. Tacan). Some investigations on the optimization of such integrated navigation systems are discussed. It will be shown, that high navigation accuracy can be obtained even with medium-performance sensors by implementation of an optimal estimation and control filter, and by the use of methods reducing the influence of some inertial sensor errors on the system performance. The basic rule for the realization of an effective integrated navigation system is to use sensors with complementary characteristics, but with mutually balanced accuracy. Author

N73-20695 Army Missile Command, Redstone Arsenal, Ala. Guidance and Control Directorate
COMPLIANT SURFACES FOR AIR BEARING GYROS
James V. Johnston *In* AGARD Inertial Navigation Components and Systems Feb. 1973 8 p refs (For availability see N73-20684 11-21)

A development study on a spherical, hydrostatic, compliant bearing for a directional gyro is discussed. The concept of the rubber air bearing and its subsequent development is traced through its analytical analysis and experimental hardware fabrication to the test results. Use of a compliant material for one of the bearing surfaces, which would grip the rigid surface when unpressurized constitutes the novel concept of self caging. Included in this paper are the basic design curves developed for the compliant bearing. Use of these curves provides the bearing engineer with the basic tools necessary to design compliant air bearings. Unusual problems encountered in the fabrication and evaluation of rubber bearings are shown and discussed. Areas of further investigation are indicated which would enhance the rubber bearing development technologies. Author

N73-20696 CIT Compagnie Industrielle des Telecommunications, Bruyeres-le-Chatel (France) Div. des Essais et des Systemes Inertiels
GAS HYDRODYNAMIC LANDING GYROSCOPE WITH TWO DEGREES OF FREEDOM: METHOD OF EVALUATING PERFORMANCE [GYROSCOPE A DEUX DEGRES DE LIBERTE SUR PALIER A GAZ HYDRODYNAMIQUE: METHODE D'EVALUATION DES PERFORMANCES]
Pierre Leger *In* AGARD Inertial Navigation Components and Systems Feb 1973 19 p refs In FRENCH (For availability see N73-20684 11-21)

Two principle means developed to measure the functions and performance of a gyroscope with two degrees of freedom are outlined. A mathematical model representing the essential characteristics of the apparatus, given the formulation of parasitic coupling of the gyroscope under constant acceleration, is described. Statistical optimization was used to analyze multi-position effects according to the type of gyroscope and numerous redundancies present in a series of measurements. Probable coefficients of the model and the uncertainties associated with these coefficients are evaluated. Transl. by E.H.W.

N73-20697 Teledyne Systems Co., Northridge, Calif.
DYNAMICALLY TUNED GYROS IN STRAPDOWN SYSTEMS
Robert J. G. Craig *In* AGARD Inertial Navigation Components and Systems Feb. 1973 26 p refs (For availability see N73-20684 11-21)

A review is presented of the basic principles of operation of the dynamically tuned instrument and shows a gyro configuration designed for the strapdown use. Characteristic errors in a multigimbal design are discussed and the basic error models for the gyro, together with its dynamic characteristics, are presented. Author

N73-20698 Air Force Avionics Lab., Wright-Patterson AFB, Ohio
THE EVOLUTION OF ESG TECHNOLOGY
Robert R. Warzynski and Ronald L. Ringo *In* AGARD Inertial Navigation Components and Systems Feb. 1973 8 p (For availability see N73-20684 11-21)

Two electrostatic gyro (ESG) navigation systems are described: the gimbaled ESG aircraft navigation system (GEANS) and the strapdown ESG micro navigator (MICRON). The ESG, its drift error sources, the exploratory program that preceded the development of the GEANS and MICRON, and the status of the GEANS and MICRON development are reported. Author

N73-20699* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PROGRESS IN STRAPDOWN TECHNOLOGY
J. C. Hung (Tenn. Univ., Knoxville) and G. B. Doane, III *In* AGARD Inertial Navigation Components and Systems Feb 1973 9 p refs (For availability see N73-20684 11-21) CSCL 17G

An overview is presented of typical inertial grade instrumentation available to mechanize precision strapdown attitude reference systems as well as a novel scheme of redundancy management, if two degree of freedom instruments are used. The instrumentation is divided between conventional and unconventional sensors with some assessment of their readiness included. Author

N73-20700 Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio
INERTIAL SYSTEM ENHANCEMENT OF FLIGHT CONTROL
Max L. Lipscomb and Fred D. Smith *In* AGARD Inertial Navigation Components and Systems Feb. 1973 11 p refs (For availability see N73-20684 11-21)

The functions of vehicle flight control to which a quality inertial system will contribute, and in a number of cases make possible, is discussed. The status of programs aimed toward more fully defining and implementing these flight control functions, including all weather landing as well as automatic steering, is outlined with the results achieved to date. Functional requirements which will be levied on the inertial system are listed and examined as to the parameters measured or computed, reliability, criticality relating to flight safety, practicality of the system for broad applications from both simplicity of operation and economical standpoints, and physical aspects. Both established and probable requirements of an acceptable system are noted. The requirements will of necessity stress the fact that such a system is a safety flight item and reliability is extremely critical. A brief survey is presented of the trends and developments toward the systems which will be required to achieve universal integration of inertial navigation system signals into the flight control system functions. Several different types of inertial systems now under development are discussed to illustrate the technology which may yield applicable systems. Author

N73-20701 Army Electronics Command, Fort Monmouth, N.J. Navigation Systems Team
DESIGN OF A KALMAN DERIVED, FIXED, GAIN, HYBRID NAVIGATION SYSTEM
W. R. Light, Jr., R. F. Clark, C. T. Elliott, M. J. Fisher, C. J. Galanti, J. A. Knight, and I. Levine *In* AGARD Inertial Navigation Components and Systems Feb. 1973 10 p refs (For availability see N73-20684 11-21)

At present, there exists a major effort to develop cost effective navigation systems for application to U S Army aircraft. Major factors involved in the design of one candidate for such an application (a loran/inertial hybrid system) are discussed. The design factors addressed include selection of a measurement processing technique to be used in conjunction with a Kalman filter algorithm and the modification of this algorithm to provide Kalman derived, fixed feedback gains, free of geographic dependence. Relative performance of the fixed gain and Kalman systems is assessed through analysis of data from both Monte Carlo computer simulations and actual flight test. Author

N73-20702 Steinheil-Lear Siegler A G, Ismaning (West Germany)

A THREE AXIS GYRO STABILIZED TORPEDO PLATFORM

Gerhard Gerber *In* AGARD Inertial Navigation Components and Systems Feb 1973 9 p (For availability see N73-20684 11-21)

The design of a three axis platform is described with dimensions of 190 mm in diameter, 225 mm in length, and a weight of 6 kg with a ready time of approximately 10 seconds. The power consumption is equal or less than 35 watts. The attitude is equal or better than 0 3 degrees in roll and pitch with a drift rate (depending on the gyro) of better than 4 deg/h in azimuth. The platform is supplied with 115 V AC, 3 phase and includes all electronics. Author

N73-20703 Technische Hogeschool Twente, Enschede (Netherlands)

DETERMINATION OF SHIPS ORIENTATION FROM ACCELEROMETER SIGNALS

R P Offereins *In* AGARD Inertial Navigation Components and Systems Feb 1973 9 p refs (For availability see N73-20684 11-21)

A method is described for determining the orientation of a ship using only signals from accelerometers and without the use of gyroscopes. Three rotation accelerometers and two translation accelerometers are necessary. They are rigidly attached to the ship. Their signals and the signal of the compass are processed by a digital computer which performs a sort of filtering process to compute continuously the three angles determining ships orientation. These angles may be used for controlling equipment like radar, guns etc. The advantage of the method as compared with a solution using gyros is the simple and reliable hardware. The critical point will be the accuracy of measurement of rotation acceleration. The computer program has been tested and now experiments are carried out to test the system with a model of a moving ship. Author

N73-20704 Marconi-Elliott Avionic Systems Ltd, Rochester (England) Inertial Navigation Div

THE USE OF A CLUSTER ROTATED INERTIAL SYSTEM IN A STRIKE AIRCRAFT ENVIRONMENT

D G Harris *In* AGARD Inertial Navigation Components and Systems Feb 1973 7 p (For availability see N73-20684 11-21)

The Jaguar inertial system is described which involves the use of spatial commutation of the horizontal inertial sensor errors to achieve the required performance. The development program concerned with the realization of the system is reviewed. A brief review of the theory of cluster rotation and its advantages is followed by description of the way the technique was applied to improve the performance of an existing platform. Other aspects of the inertial navigation system where the design was influenced by the use of the rotation technique are then described. The sequence of laboratory and flight trails during which problem areas were discovered and the methods for solving the problems are discussed. Author

N73-20705 Boeing Co, Seattle, Wash

DESIGN OPTIMIZATION OF SRAM INERTIAL NAVIGATION AND GUIDANCE

J H Whiting and R D Thomas (SRAM System Program Office) *In* AGARD Inertial Navigation Components and Systems Feb 1973 10 p (For availability see N73-20684 11-21)

Since the AGARD Inertial Navigation Symposia in 1967 and 1968, the short range attack missile (SRAM) has progressed from the design phase into production. The United States Air Force's newest strategic weapon is now entering the inventory and will become operational later this year with the first wing of B-52 aircraft modified to carry it. Navigation, guidance and transfer of alignment techniques which were being developed in 1968 have been incorporated into the weapon system and successfully demonstrated on 30 flight tests. A general description of SRAM, unique features of the SRAM inertial navigation and guidance system, and the considerations which led to the final design are presented. Emphasis is placed on in-flight inertial navigation alignment and calibration, and design features which minimize cost. Author

N73-20706 Bodenseewerk Geraetetechnik G m b H, Ueberlingen (West Germany)

ADVANCED PROCEDURES FOR SELF-ALIGNMENT AND CALIBRATION OF INERTIAL PLATFORMS

U K Krogmann *In* AGARD Inertial Navigation Components and Systems Feb 1973 18 p refs (For availability see N73-20684 11-21)

Starting with the nonlinear and linear model of the IMU in the gravity field of the rotating earth it is shown that the state-vector normally cannot be measured directly. An optimal estimator is necessary to estimate system state at discrete time. Different estimation techniques applicable for alignment and calibration are treated in detail and compared with respect to complexity and efficiency. Closed loop as well as quasi-closed loop techniques are contemplated using Kalman-Filter and weighted least squares. The problem of estimator divergence is discussed briefly. Author

N73-20707 Institut fuer Flugnavigation, Stuttgart (West Germany)

PROCEDURES FOR THE ESTIMATION OF THE IN-FLIGHT VERTICAL MISALIGNMENT OF PLATFORMS

Volkmar Held *In* AGARD Inertial Navigation Components and Systems Feb 1973 16 p refs (For availability see N73-20684 11-21)

Test flight measurements were made with a single-axis inertial platform mounted in a Transall C 160 test aircraft. For additional velocity information the outputs of the Doppler radar were used. The estimation of the platform vertical misalignment is performed in two different ways with a so called mean value procedure which needs only the integral of the platform accelerometer output and the appropriate component of the Doppler velocity and with a Kalman filter. The dynamic and statistic values which are necessary to implement the filter are determined from the flight measurements. Different filter models result in dependence on the platform horizontal reference axis orientation relative to the aircraft and on the aircraft acceleration according to gusts. The results of the platform misalignment estimation show that the application of a Kalman filter procedure leads in all treated cases to the best estimation accuracy if an additional velocity measurement is used. If no doppler velocity measurement is available for the estimation the errors are so large that it is not worthwhile to apply the sophisticated Kalman filter. Author

N73-20708 Deutsche Forschungs und Versuchsanstalt fuer Luft und Raumfahrt, Brunswick (West Germany) Inst fuer Flugfuehrung

THE MODELLING ERROR SENSITIVITY OF DIGITAL FILTERS FOR THE ALIGNMENT OF INERTIAL PLATFORMS

Heinz Winter *In* AGARD Inertial Navigation Components and Systems Feb 1973 15 p refs (For availability see N73-20684 11-21)

The effect of incorrect or incomplete modelling of a typical inertial platform in sub-optimal filters on the alignment and calibration accuracy is analyzed. Closed-loop alignment with a 13-dimensional Kalman filter and open-loop alignment with a 4-dimensional regression filter are considered. Simplifications of the precomputed gain matrix and a fairly simple controller for closed-loop alignment are analyzed with respect to their effect on the alignment accuracy. It is shown that the modelling errors in the 4-dimensional regression filter lead to increasing uncertainty in the platform state estimation after a certain estimation time. The limitation of the azimuth alignment accuracy caused by the east gyro drift is discussed for different drift correlation times between 1.5 seconds and infinite time and is compared with the steady state azimuth alignment error in a third order gyrocompassing loop. Author

N73-20709 Ferranti, Ltd. Edinburgh (Scotland). Inertial Systems Dept.

GYRO CHARACTERISTICS FOR RAPID GYRO-COMPASSING

K. R. Brown and D. Anderson *In* AGARD Inertial Navigation Components and Systems Feb. 1973 18 p ref (For availability see N73-20684 11-21)

Inertial navigation system alignment, of course, includes finding north by gyrocompassing, and around 2.5 minutes must be met if the overall reaction time of the aircraft is not to be limited by the system. It is found that for all practical purposes the equipment must be switched on from cold and this necessitates the use of the inertial instruments before they reach their designed operating temperature. The results are given of a program of work over many years, to determine the parameters of single-axis floated gyroscopes, when used in inertial systems requiring rapid reaction under these conditions. New parameters of gyro drift have been obtained, and the new technique of system operation based on these is outlined. The performance obtained with an inertial navigation system using these techniques is given to illustrate the benefits to be gained. Author

N73-20710 LTV Aerospace Corp. Dallas, Tex.

A-7 AIRCRAFT AIRBORNE, GROUND, AND SHIPBOARD INERTIAL NAVIGATOR ALIGNMENT METHODOLOGY AND RESULTS

M. G. Johnson, Jr. *In* AGARD Inertial Navigation Components and Systems Feb. 1973 10 p (For availability see N73-20684 11-21)

The A-7D/E aircraft navigation system is described and in particular the alignment method. The particular functions which the system performs are outlined. The alignment techniques are described in a basic fashion without delving into a detailed derivation. Finally, some experience gained during the A-7 program is presented along with test results. Author

N73-20711 Norwegian Defence Research Establishment, Kjeller. Div. of Electronics.

PENGUIN MISSILE INERTIAL NAVIGATION SYSTEM. DESIGN CONSIDERATION FOR MIDCOURSE GUIDANCE

H. K. Johansen *In* AGARD Inertial Navigation Components and Systems Feb. 1973 13 p (For availability see N73-20684 11-21)

The midcourse guidance of the Penguin ship to ship missile requires an inertial navigation system for attitude reference and position computation. The INS has a three axis platform with resolver outputs to the guidance system and seeker head. The cross-track position is computed by analog electronics. Later versions also incorporate down range navigation electronics. The mechanical design emphasizes simplicity in assembling and maintenance by making use of a complete package design. A rapid initialization technique for use on board small fast patrol boats is described. In azimuth resolver slaving is used and leveling is performed by using the platform accelerometers and by compensating for the ship horizontal accelerations. A modified tangent plane navigation scheme is used in the flight mode. Navigation accuracy better than 200 m at 25 km has been demonstrated. Results from error simulations and results from a rocket sled test program are shown. Author

N73-20712 Royal Aircraft Establishment, Farnborough (England). Avionics Dept.

FAULT DETECTION POSSIBILITIES IN A SYSTEM EMPLOYING KALMAN FILTERING

F. Gregson *In* AGARD Inertial Navigation Components and Systems Feb. 1973 10 p refs (For availability see N73-20684 11-21)

Kalman filtering is coming into use as a means of mixing sensor information in an integrated navigation system. Use of the technique, implying knowledge of the errors in the system and their statistics, should provide a basis for fault detection. The report quotes the basic Kalman filtering equations and discusses the indirect implementation normally used in airborne navigation applications. Types of faults in the sensors are categorized according to the way in which they would affect the operation of Kalman filtering. Criteria are established for detecting each category of fault. These are discussed with reference to a Doppler-inertial navigation system. The methods proposed for the detection of faults are shown to be relevant to the problem of divergence encountered in some Kalman filter implementations. It is concluded that it should be possible to detect faults. Location however may not be possible. Author

N73-20713 Singer Co., Little Falls, N.J. Aerospace and Marine Systems Group.

FAULT ISOLATION AND MAINTENANCE CONCEPTS OF AN ADVANCED INERTIAL NAVIGATION SYSTEM

Francis H. Murphy *In* AGARD Inertial Navigation Components and Systems Feb. 1973 9 p (For availability see N73-20684 11-21)

The design concepts, hardware characteristics, and system tradeoffs are described which have been considered for a self-contained advanced inertial navigation system. Included in this system is an automatic self-annunciating fault isolation capability. The system is packaged in a single LRU and has been organized to be modular in construction with fault annunciation to both the module level for flight line level maintenance and to the functional circuit hybrid chip at the intermediate level. Details are presented on the various built-in test functions, as well as validation of the built-in test hardware by utilization of the BITE-on-BITE concept. Software monitoring is discussed, including built-in flight line self-test, calibration and in-flight performance monitoring utilizing existing redundancy within the platform subsystem. The utilization of a calibration computer card is also discussed. This card, an interchangeable replacement for the operational computer card, is utilized to perform periodic calibration of the platform subsystem without the need for any additional external support calibration equipment. The report concludes with a summary of the methods used to fault isolate and the maintenance action required at the various operational levels. Author

N73-20714 Laboratoire de Recherches Balistiques et Aerodynamiques, Vernon (France).

ACTIVITIES OF LRBA IN THE INERTIAL DOMAINE [ACTIVITES DU LRBA DANS LE DOMAINE DE L'INERTIE]

Jean Moret and Guy Cally *In* AGARD Inertial Navigation Components and Systems Feb. 1973 12 p In FRENCH (For availability see N73-20684 11-21)

The role of LRBA in inertial affairs relative to French military programs and the methods used by the facility to study these systems are briefly outlined. Qualification tests of accelerometer systems for ballistic engine guidance, in environments simulated on a centrifuge, are discussed in detail. Transl. by E.H.W.

N73-20715 Laboratoire de Recherches Balistiques et Aerodynamiques, Vernon (France).

DETERMINATION OF NONLINEAR ACCELEROMETERS BY A METHOD OF DIFFERENTIAL TESTS [DETERMINATION DES NON LINEARITES D ACCELEROMETRES PAR UNE METHODE D'ESSAIS DIFFERENTIELS]

Jean Moret and Guy Cally *In* AGARD Inertial Navigation Components and Systems Feb. 1973 8 p In FRENCH (For availability see N73-20684 11-21)

A differential test method used to evaluate the quality and performance of nonlinear accelerometers is described. Advantages of the method over classical methods, measurement errors, and the results obtained are given. Transl by E H W

N73-20716 Royal Aircraft Establishment, Farnborough (England) Avionics Dept
DATUM POSITIONS AND VELOCITIES FOR THE EVALUATION OF INERTIAL NAVIGATION SYSTEMS
R F Stokes and S G Smith *In* AGARD Inertial Navigation Components and Systems Feb 1973 21 p (For availability see N73-20684 11-21)
The methods are described which were employed to obtain datum position and velocity information for use in evaluating inertial navigation systems with a performance of around 1 n mile/h. The methods were designed to permit evaluations on a world-wide basis using whatever sources of position information are available. These are usually two inertial navigation systems, a Doppler dead reckoning position, range-range Tacan or DME, Decca, and loran C. The datum produced has to be accurate enough, and in a suitable form, for use in trying to identify the major sources of system error in the inertial navigation system under test. A lower accuracy datum, only suitable for use in statistical analyses, is also described. Various examples are given of the accuracies of the methods, of the quality of inertial navigation system error information obtained, and of the errors observed in Tacan, Decca and loran C fixes. The methods for identifying error sources are related to the type of datum obtained. The virtues of range-range Tacan, Decca, and loran C for providing fixes for these types of evaluation are also discussed. Author

N73-20717 Aerospace Guidance and Metrology Center, Newark Air Force Station, Ohio Plans and Management Staff Office
LIFE CYCLE COST ANALYSIS OF INERTIAL SYSTEMS FOR AIRCRAFT AND AIR TO SURFACE MISSILES
Donald L Hardy Jr and Russell M Genet *In* AGARD Inertial Navigation Components and Systems Feb 1973 5 p refs (For availability see N73-20684 11-21)
Life cycle cost analysis of Inertial Navigation Systems (INS) is becoming more significant to all users today as performance goals more closely achieve their objectives. Cost of ownership models and analyses were developed that contribute to current and future assessments of this important area. These analyses are based on an extensive accumulation of inertial systems data. The current analyses include a critical assessment of the current model and its data, a taxonomic analysis of INS applications, and a sensitivity analysis of all input model parameters. These analyses have led to development of new models which will more accurately predict the cost of ownership of a given inertial system. The primary usefulness of the models will be for (1) generalized analysis of, and (2) discrimination between, the cost of ownership of aircraft and air to surface missile inertial systems. Specific references are made to the most sensitive parameters of any cost of ownership analysis concerning inertial navigation systems. These parameters are of great use in knowing how little data is actually needed to make management and technical discussions. The types of decisions and applications managers and design personnel need to make concerning inertial systems are also outlined. Author

N73-23689# Advisory Group for Aerospace Research and Development, Paris (France)
AIR TRAFFIC CONTROL SYSTEMS
Apr 1973 371 p refs In ENGLISH and FRENCH Presented at the 14th Meeting of the Guidance and Control Panel of AGARD Edinburgh, 26-29 Jun 1972
(AGARD-CP-105) Avail NTIS HC $20.75
The proceedings of a conference on air traffic control developments and procedures are presented. The subjects discussed involve the following: (1) control concepts, (2) automation, (3) area and enroute navigation, (4) terminal navigation and control, (5) landing guidance, (6) surveillance, (7) communications, (8) collision avoidance, and (9) integrated communication, navigation, and identification system. For individual titles, see N73-23690 through N73-23721.

N73-23690 Electronic Systems Div, Bedford, Mass
STATUS AND TRENDS IN MILITARY AIR TRAFFIC CONTROL SYSTEMS
Albert R Shiely, Jr *In* AGARD Air Traffic Control Systems Apr 1973 3 p (For availability see N73-23689 14-21)
The status and trends in military air traffic control systems are discussed. The air navigation facilities operated by U S Military Forces are described. The mission of the Air Defense Control System is explained. The development of automated air control systems, airborne search radar, and integrated communication, navigation, and identification systems is reported. Author

N73-23691 Eurocontrol Agency, Brussels (Belgium)
AIR TRAFFIC CONTROL IN THE EUROCONTROL AREA
G H Trow *In* AGARD Air Traffic Control Systems Apr 1973 18 p (For availability see N73-23689 14-21)
The organization and operation of the Eurocontrol area air traffic control system are discussed. The member nations comprising the organization are identified. The accomplishments of the organization are presented. The problems peculiar to European flights because of national sovereignty are analyzed. The development of an improved system of air traffic control is reported. Maps of the Eurocontrol area of operation are included. Author

N73-23692 Wilcox Electric Co, Inc, Kansas City, Mo
DECISIONS FOR THE 70'S
Robert J Shank *In* AGARD Air Traffic Control Systems Apr 1973 15 p (For availability see N73-23689 14-21)
The nature of the air traffic control system and procedures during the 1970's are almost completely determined by decisions made during the past twenty years. A brief review of this already-determined baseline system and its operation is included, and a set of objectives for the future and guiding principles will provide a background for the major decisions now confronting the world air traffic control community. The important proposed changes or improvements in the areas of surveillance, navigation, communications, collision avoidance, and instrument landing are examined, and the major issues for decision are proposed. Author

N73-23693 National Aerospace Lab, Amsterdam (Netherlands)
ATC AUTOMATION, PRESENT AND FUTURE
C G H Scholten *In* AGARD Air Traffic Control Systems Apr 1973 5 p refs (For availability see N73-23689 14-21)
A number of design principles in which future air traffic control systems should differ from present systems in order to cope with increased air traffic demands are discussed. The principles are that available air space and airports should be used in as flexible a manner as possible by using computers and that improved data links between ground and air will be required for pilot-computer communication. The need for a back up system in the event of complete computer failure to allow controllers to clear existing traffic safely is proposed. Author

N73-23694 IBM Italia, Rome
AUTOMATION OF AIR TRAFFIC CONTROL IN ITALY, ROME CONTROL AREA
Camillo Martucci and Bruno Tincani *In* AGARD Air Traffic Control Systems Apr 1973 10 p (For availability see N73-23689 14-21)
The physical structure and operative unit organization of the Rome, Italy air traffic control system are discussed. The automation of the system is described to include the functions and capabilities. The phases in which the automated system is being implemented are reported. Diagrams of the system components and network to show the operation of the system are provided. Author

N73-23695 Centre d'Experimentation de la Navigation Aerienne, Orly (France)
THE SAVVAN: MEANS FOR INSPECTION BY VOR AND DME [LE SAVVAN, MOYEN D'INSPECTION DES VOR ET DES DME]
Gilbert Montel *In* AGARD Air Traffic Control Systems Apr 1973 11 p In FRENCH (For availability see N73-23689 14-21)

An evaluation is presented of the effectiveness of the S⁄⁄VAN (automatic system for verification of navigation aids in flight) in locating and controlling high altitude aircraft. The system responds to signals from VOR and DME onboard the aircraft. Signals are registered on a magnetic band where they are processed according to a pre-established computer program. Along with the magnetic band, the system has logic elements and 12 receivers. Transl. by E.H.W.

N73-23696 Federal Aviation Administration, Washington, D.C.
STATUS AND TRENDS IN CIVIL AIR TRAFFIC CONTROL SYSTEMS
Gustav E. Lundquist *In* AGARD Air Traffic Control Systems Apr. 1973 5 p (For availability see N73-23689 14-21)

The status and trends on civil air traffic control systems are discussed. The use of automation programs to increase air traffic control safety by providing the air traffic controller with better information on which to base decisions is examined. The development of a network of computers, displays, and communications which will process, store, and distribute instrument flight rules is reported. The operation of the system is described by illustrations and block diagrams. Author

N73-23697 Singer-Kearfott, Fairfield, N.J.
AREA NAVIGATION: COST VERSUS OPERATIONAL BENEFITS
Jefferson Z. Amacker *In* AGARD Air Traffic Control Systems Apr. 1973 9 p refs (For availability see N73-23689 14-21)

Cost, complexity, and cockpit workload were compared for seven potential area navigation system configurations. Cockpit workload was found to be minimum for the very simple and most sophisticated systems. However, the sensitivity of the cost parameter is such that it increases dramatically with system complexity with relatively little gain in operational benefit. A detailed study of the Mark 1, Mark 13, and ATA Operations Committee requirements document discerned that almost all required operational functions could be accomplished with minimum systems. Author

N73-23698 Litton Systems, Inc., Woodland Hills, Calif. Aero Products Div.
AIRBORNE AREA NAVIGATION EQUIPMENT
C. S. Bridge and R. J. Holm *In* AGARD Air Traffic Control Systems Apr. 1973 13 p (For availability see N73-23689 14-21)

A broad base of area navigation equipment, manufacturers and users exists. Types of equipment extend from simple adaptation of VOR to triple inertial systems with multiple radio position inputs and digital computer processing. Air transport equipment is grouped into Mark I, Mark II and Mark 13 systems which are described. Area navigation systems are based upon, or augmented by, air data, VOR, Doppler, inertial, Loran A/C, Omega, and satellite. Demonstrations and performance in recent flight tests show state-of-the-art for area navigation systems with consideration of projected requirements. Examples of enroute navigation, vertical navigation, terminal area and landing are shown. Controls, pictorial displays, automatic data entry and data link are discussed. Author

N73-23699 Systems Control, Inc., Palo Alto, Calif.
AN ATC/SURVEILLANCE MODELING APPROACH FOR SPECIFYING LANE SEPARATION STANDARDS
J. S. Tyler, D. E. Stepner, and J. A. Sorensen *In* AGARD Air Traffic Control Systems Apr. 1973 12 p refs (For availability see N73-23689 14-21)
(Contract DOT-TSC-260)

The reduction in separation standards for both domestic and oceanic air routes because of increased travel demand is discussed. The overall problem of relating lane separations to safety for different navigation systems, surveillance systems, and air traffic control procedures are considered. A model is described which has the same general input/output format as the Reich model that has been used for specifying North Atlantic route separations. Numerical results are presented to show the impact of inertial navigation systems and satellite surveillance on the separation standards and safety for the North Atlantic route structure. Author

N73-23700 Aerospace Systems, Inc., Burlington, Mass.
ANALYSIS OF TERMINAL ATC SYSTEM OPERATIONS
Richard B. Noll, John Zvara, and Robert W. Simpson (MIT) *In* AGARD Air Traffic Control Systems Apr. 1973 15 p refs (For availability see N73-23689 14-21)
(Contract DOT-TSC-103)

The effects of automation in terminal air traffic control are analyzed with respect to the impact of the automation on the controller. The present air traffic control system based on radar information and manual techniques is discussed and compared with an advanced system which uses a computer to generate alphanumeric radar displays and automated features. A typical control operation is presented to demonstrate controller activity in both the present and an advanced system. ARTS I is used to represent the advanced air traffic control system. The principal features of ARTS I are described and the interface of the controller with the computer and the display equipment is discussed. Author

N73-23701* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AN ANALYTIC STUDY OF NEAR TERMINAL AREA OPTIMAL SEQUENCING AND FLOW CONTROL TECHNIQUES
Stephen K. Park, Terry A. Straeter, and John E. Hogge *In* AGARD Air Traffic Control Systems Apr. 1973 18 p refs (For availability see N73-23689 14-21)

Optimal flow control and sequencing of air traffic operations in the near terminal area are discussed. The near terminal area model is based on the assumptions that the aircraft enter the terminal area along precisely controlled approach paths and that the aircraft are segregated according to their near terminal area performance. Mathematical models are developed to support the optimal path generation, sequencing, and conflict resolution problems. Author

N73-23702 Air Line Pilots Association, International, Washington, D.C.
A REAL WORLD SITUATION DISPLAY FOR ALL WEATHER LANDING
J. L. DeCelles, E. J. Burke, and Ken Burroughs *In* AGARD Air Traffic Control Systems Apr. 1973 9 p (For availability see N73-23689 14-21)

A flight data display for use in aircraft approach and landing under all conditions of visibility is described. The device provides airborne self-contained glide path guidance for use in visual flight conditions. In its most sophisticated form it provides total information for manual landing, or monitoring automatic landing and roll-out during reduced visibility. It is stated that the heads up display symbology similar to that described is urgently required for see-to-land approaches and will be essential for pilot acceptance of automatic landings in actual nonvisual conditions. Author

N73-23703 Royal Aircraft Establishment, Bedford (England). Blind Landing Experimental Unit.
THE INFLUENCE OF THE FUTURE LANDING GUIDANCE SYSTEM ON INTEGRATION OF SHORT TAKE-OFF AND LANDING AND CONVENTIONAL AIR TRAFFIC AT A MAJOR AIRPORT
Nigel H. Hughes *In* AGARD Air Traffic Control Systems Apr. 1973 17 p refs (For availability see N73-23689 14-21)

Some of the benefits to air traffic control which may result from deploying landing guidance systems are identified. The characteristics of short takeoff and landing aircraft intercept of the instrument landing system localizer and final approach path are studied and the final approach geometry is established. STOL approach sequencing requirements are defined and sequencing geometry suggested. The [illegible]ility of nonvisual approach and landing guidance systems to ease air traffic control problems is discussed. Avionics developments which are required to allow aircraft to take advantage of future landing guidance systems are described. Author

N73-23704 Army Electronics Command, Fort Monmouth, N J
US ARMY AIR TRAFFIC MANAGEMENT NOW THROUGH 1980
Charles Grossman and Thomas E Daniels *In* AGARD Air Traffic Control Systems Apr 1973 11 p (For availability see N73-23689 14-21)

The requirements of an air traffic management system which will be capable of providing for the safe operation of large numbers of aircraft under instrument meteorological conditions (IMC) and thus afford the commander maximum utilization of his combat capability within reasonable constraints of money and equipment, a totally integrated ground and airborne system, are discussed. The requirements are based upon the assumption that the Army will continue to exploit and expand the air mobility concept in the future. In order to accrue the maximum benefits from such a concept the field commander must be afforded the means to effectively use his aircraft with minimum constraints. The absence of such a system currently precludes effective field exploitation of Army aircraft under adverse weather and visibility conditions, and furthermore precludes the onset of operations until weather predictions give reasonable assurance of resupply/evacuation. Author

N73-23705 Honeywell, Inc, Minneapolis, Minn Government and Aeronautical Products Div
FUNCTIONAL DESIGN OF MICROWAVE LANDING SYSTEM (MLS) AIRBORNE EQUIPMENT AS INFLUENCED BY GROUND EQUIPMENT CONFIGURATION AND AIRCRAFT TYPE
Donald N Carlson and Charles L Seacord *In* AGARD Air Traffic Control Systems Apr 1973 10 p refs (For availability see N73-23689 14-21)

A description of a proposed microwave landing system (MLS) is presented, with particular emphasis on the functional design requirements of the airborne equipment. This system has the potential of meeting the expanded, more precise, and more complex needs generated by a growing aircraft population consisting of both conventional and unconventional (V/STOL) types. A modular approach to both ground and airborne equipment is identified as a means of achieving desired flexibility and low cost required for a truly universal system serving the full spectrum of user aircraft and aircraft types. Elements of the ground system are identified and their influence on the nature of the transmitted signal is described. Author

N73-23706 ITT Gilfillan, Inc, Van Nuys, Calif
THE PERFORMANCE OF THE DOPPLER MICROWAVE LANDING SYSTEM IN A MULTIPATH ENVIRONMENT
R. A. Rosien and L L Sanders *In* AGARD Air Traffic Control Systems Apr 1973 9 p (For availability see N73-23689 14-21)

The success of the Doppler microwave landing system in meeting the multipath challenge is described. Techniques which can be used to eliminate the effects of multipath are described. The various multipath sources are listed together with the specific requirements for each. Performance data is given which has been gathered from three sources (1) computer simulation, (2) laboratory tests of an equipment model, and (3) field tests on two experimental Doppler systems. The data indicates that the Doppler MLS, utilizing the simplest form of signal processing, namely, a filter and zero crossing counter, may be adequate under limited accuracy and siting conditions. For performance in heavy multipath, some form of narrowband device will probably have to be employed in order to satisfy the accuracy and minimum coverage angle requirements. Author

N73-23707 Informasjonskontroll A/S, Asker (Norway)
LANDING GUIDANCE SYSTEM: HERMES
Nils Holme *In* AGARD Air Traffic Control Systems Apr 1973 8 p (For availability see N73-23689 14-21)

The basic principles of the landing guidance system Hermes are described. The system is based on the establishment and detection of a coded pattern of gamma radiation from radioactive sources. This principle offers a remarkable combination of high accuracy, extreme reliability and low cost, especially when applied to the final approach and runway for conventional/short takeoff and landing operations. The ground installation is purely mechanical, with no moving parts. All information is air-derived. Author

N73-23708 Royal Aircraft Establishment, Farnborough (England). Radio Dept
A FORWARD AREA HOMING AND LANDING GUIDANCE CONCEPT FOR MILITARY AIRCRAFT
Ian M. Hunter *In* AGARD Air Traffic Control Systems Apr 1973 8 p (For availability see N73-23689 14-21)

The characteristics of a forward area homing and landing guidance concept for military aircraft are discussed. The relative advantages of air-derived and ground-derived concepts are compared. It is concluded that a pure air-derived system cannot meet the military requirements. The development of a hybrid solution is proposed. Author

N73-23709 Aerospace Corp, Los Angeles, Calif. Development Planning Div
THE POTENTIAL OF A SYSTEM OF SATELLITES AS A PART OF AN AIR TRAFFIC CONTROL SYSTEM
P. M Diamond *In* AGARD Air Traffic Control Systems Apr 1973 17 p (For availability see N73-23689 14-21)

The air traffic control (ATC) performance potential of satellite systems utilized in a data acquisition and communications role within a continental United States (CONUS) ATC system is discussed. The unique properties of satellite-based relays provide the only viable means of achieving complete coverage to ground level of the entire airspace, coupled with uniform and highly accurate surveillance position fixing. Position determination, identification, flow control, and collision avoidance functions can be implemented through the use of regional centralization of ground computation, resulting in important benefits to the utilization of the airspace and adaptability of the ATC system. It is shown that the concept of intermittent positive control (IPC) requires aircraft speed/acceleration restrictions and leads to the requirement for surveillance accuracies of 100 to 200 ft within the densely populated regions of airspace expected in the 1980s. A class of satellite systems is described which offers the requisite performance for both commercial carriers and general aviation with low anticipated costs of aircraft equipment. Author

N73-23710 Service Technique de la Navigation Aerienne, Paris (France)
TAM-TAM SYSTEM [SYSTEME TAM-TAM]
Jacques Louet *In* AGARD Air Traffic Control Systems Apr 1973 11 p In FRENCH (For availability see N73-23689 14-21)

The TAM-TAM (automatic transmission of messages of air traffic by multiplex) system as a possible data link in air-ground-air transmission during oceanic, continental, and terminal control area flight is discussed. Problems encountered and solutions to those problems are included. Transl by E H W

N73-23711 Mitre Corp, Bedford Mass
DERIVATION OF A WIDE AREA POSITION LOCATION CAPABILITY USING A SYNCHRONIZED TIME DIVISION MULTIPLE ACCESS COMMUNICATION SYSTEM
Victor A DeMarines and R L Thompson (ESD) *In* AGARD Air Traffic Control Systems Apr 1973 10 p ref (For availability see N73-23689 14-21)

A concept for the use of a high bandwidth time division communications system to provide a ground based, wide area, position location system is presented. General principles upon which the system is based and a discussion of computational techniques employed are covered. A discussion of system behavior as a function of system [illegible] random errors caused by individual element position uncertainty and geometric effects is included. Control mechanisms required to produce stable and reliable performance are also described. Results of a computer simulation are presented to provide estimates of capability under various conditions and to establish the system performance envelope. Author

N73-23712 Radio Corp. of America, Van Nuys, Calif. Electromagnetic and Aviation Systems Div
SECANT: A SOLUTION TO THE PROBLEM OF MID-AIR COLLISIONS
J. L. Parsons *In* AGARD Air Traffic Control Systems Apr 1973 11 p ref (For availability see N73-23689 14-21)

The principal characteristics of SECANT, a system for the separation and control of aircraft using non-synchronous Techniques, are described. This cooperative, transponding collision-avoidance system, designed to be compatible within the entire aviation community, is capable of accommodating the dense air traffic anticipated for the 1980s and beyond. It makes available to the pilot evasion or escape maneuvers in any direction - vertical, horizontal, or a combination. SECANT helps the pilot to avoid mid-air collisions by transmitting probes and receiving replies with a 1 microsecond pulse at 1000 pulses per second on 24 different frequencies. Various discriminants are used to eliminate undesired signals, and the false alarm rate is near zero. Author

N73-23713 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
A FRENCH COLLISION: AVOIDANCE SYSTEMS OF TIME-FREQUENCY TYPE. CRITICAL ANALYSIS OF TEST RESULTS
Roland Moreau *In* AGARD Air Traffic Control Systems Apr 1973 9 p refs In FRENCH, ENGLISH summary (For availability see N73-23689 14-21)

Performance tests of a system for air traffic control and collision avoidance are discussed. The system is described and the method of operation is outlined. The precision obtained is analyzed and compared with established standards. Modifications of the signal format are examined. Problems raised by the introduction of the new air traffic control system are reported. Author

N73-23714 Royal Air Force Inst. of Aviation Medicine, Farnborough (England)
HUMAN FACTORS PROBLEMS IN CONFLICT DETECTION AND RESOLUTION
V. D. Hopkin IN AGARD Air Traffic Control Systems Apr 1973 8 p ref (For availability see N73-23689 14-21)

Conflict detection and resolution as human factors problems in air traffic control are discussed. It is contended that this assumption is probably incorrect, primarily because of the large differences in urgency, information, procedures and facilities in various phases of flight. The controller's responses depend on the confidence he has in the data available to him, and on his knowledge of how accurate it is likely to be. Automated aids may not be properly used if they include no indication of the accuracy, quality and comprehensiveness of the data on which automated computations are being made. Relevant research methods for human factors studies on conflict detection and resolution are indicated. Author

N73-23715 Ferranti, Ltd., Bracknell (England) Digital Systems Div
PROBLEMS INVOLVED IN ATC AUTOMATION
David L. Stoddart *In* AGARD Air Traffic Control Systems Apr 1973 11 p (For availability see N73-23689 14-21)

The two major problems involved in A.T.C. automation, suitable man-machine interfaces and system reliability, are considered. These problems are placed in perspective by examining the need for automation and by considering the information required by the controller, and how this should be displayed. Suggested man-machine interfaces are examined, including synthetic plan displays, tabular displays, touchwires, keyboards, rolling balls and light pens. The operational and technical advantages and disadvantages of these devices are discussed. The problem of reliability is introduced and the need for fail safe systems explained. Various methods of achieving reliability are considered, including triplicated hardware and systems having preferred and reconfigured functional organization. The implications of these systems are discussed and a system design suggested. Author

N73-23716 Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario)
THE MAN-COMPUTER INTERFACE PROBLEM IN TERMINAL AUTOMATION
Leslie Innes *In* AGARD Air Traffic Control Systems Apr 1973 6 p refs (For availability see N73-23689 14-21)

The main concern in the several large air traffic control automation programs which have been implemented has been the provision of information to the controller in a more accurate and more easily assimilable form. The aim was, if not to reduce the controller's workload, to at least keep it within acceptable limits. Experience with these systems to date is reviewed, and the conclusion reached that in few instances has this aim been achieved. Without adequate isolation of the controller from the requirement to continually interact with the computer, workload is inevitably increased to an unacceptable degree, due to the additional tasks imposed on the controller by the demands of the automated aspects of the system. The development of the Canadian Forces automated terminal control concept involved evaluation of several methods of simplified man-computer interaction, carried out within constraints imposed by limited available manpower in the controller trade, and limited funding for the program. A solution has been developed which appears to adequately act as a compromise between these conflicting requirements. Author

N73-23717 Laboratoire Central de Recherches Thomson-CSF, Orsay (France)
INTEGRATION OF COMMUNICATION FUNCTIONS, NAVIGATION, IDENTIFICATION, AND TRAFFIC CONTROL [INTEGRATION DES FONCTIONS DE COMMUNICATION, DE NAVIGATION, D'IDENTIFICATION ET DE CONTROLE DE TRAFIC]
L. Milosevic and P. Mollie (Service Tech. des Telecomm. de l'Air) *In* AGARD Air Traffic Control Systems Apr 1973 11 p In FRENCH (For availability see N73-23689 14-21)

The economic aspects of replacing separate aircraft landing and anticollision equipment with an integrated time-frequency system are discussed in detail. A comparison was also made of the relative cost value of replacing equipment mounted on the aircraft. Transl. by E.H.W.

N73-23718 Department of Transportation, Washington, D.C.
SATELLITE CONSIDERATIONS IN FUTURE AIR TRAFFIC CONTROL SYSTEMS
D. E. Findley *In* AGARD Air Traffic Control Systems Apr 1973 9 p (For availability see N73-23689 14-21)

A program for improving the air traffic control system of the United States is discussed. The program is involved with deployment and implementation of major improvements for certain enroute and terminal area air traffic control functions. Development efforts are proposed for the following subjects: (1) traffic surveillance, (2) conflict prediction, (3) resolution and avoidance, (4) landing guidance, and (5) automation of air traffic control functions. The background for the formulation of a concept of the air traffic control system for the 1980 time period and beyond is considered. Emphasis is placed on the use of artificial satellites to meet the air traffic demands. Author

N73-23719 TRW Systems Group, Redondo Beach, Calif.
CONCEPTUAL ANALYSIS OF ICNI SYSTEMS
J. H. Craigie *In* AGARD Air Traffic Control Systems Apr 1973 7 p refs (For availability see N73-23689 14-21)

The development of an improved communications, navigation and identification (ICNI) system for command and control, air traffic control, and mission execution is discussed. The program is mainly directed toward the requirements of four major Air Force Commands. The special requirements for each type of Air Force mission are analyzed to show the variations required in the proposed system. Author

N73-23720 Mitre Corp., Bedford, Mass.
A PRACTICAL DESIGN OF AN ICNI SYSTEM
C. Eric Ellingson *In* AGARD Air Traffic Control Systems Apr. 1973 14 p (For availability see N73-23689 14-21)

The key factors which have resulted in the proliferation of communications, navigation, and identification equipment in aircraft are discussed. The advantages of interconnective communications capability and common position location capability in reducing complexity of the system while improving operational capability are examined. A specific candidate communication system is proposed and its capabilities are analyzed. Author

N73-23721 Office of the Secretary of Defense (Research and Engineering), Washington, D.C.
INTEGRITY OF ICNI SYSTEMS
Robert Lyle Linden *In* AGARD Air Traffic Control Systems Apr. 1973 3 p (For availability see N73-23689 14-21)

An analysis of integrated communications, navigation, and identification systems for aircraft operation is presented. Advances in electronics solid state devices, logic circuits, and discrete function modules are described to show application to systems integration. The anticipated improvements in operational capability through system integration are analyzed. Author

N74-14345# Advisory Group for Aerospace Research and Development, Paris (France)
TESTING PHILOSOPHY AND METHODS OF GUIDANCE AND CONTROL SYSTEMS AND SUBSYSTEMS
Oct 1973 210 p refs Partly in FRENCH and in ENGLISH (AGARD-LS-60) Avail NTIS HC $12.50

The proceedings of a conference on performance testing guidance and control systems for aircraft and spacecraft are presented. The subjects discussed are (1) vertical acceleration tests, (2) centrifuge testing of inertial systems, (3) altitude control unit for sounding rockets, (4) evaluation of electro-optically aided space navigation systems, (5) standardization of software and hardware for test systems, (6) testing of aircraft navigation systems with a high precision reference, and (7) inertial guidance system tests using rocket propelled sleds. For individual titles, see N74-14346 through N74-14356

N74-14346 Central Inertial Guidance Test Facility, Holloman AFB, N Mex
INTRODUCTORY REMARKS: TEST TECHNOLOGY TRENDS
Martin G Jaenke *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 3 p (For availability see N74-14345 05-21)

The trends and approaches taken to solve the problems involved in testing components of inertial navigation systems are discussed. The activities of a test facility are described and importance of reliability analysis as a part of the performance tests is emphasized. The aspects of systems testing which are analyzed are (1) test accuracy, (2) test stimuli, (3) test dynamics, and (4) test efficiency Author

N74-14347 Laboratoire de Recherches Balistiques et Aerodynamiques, Vernon (France)
PIGA ACCELERATION TESTS ON VERTICAL 10G, 3 HERTZ TABLE
Michel Corsat *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 15 p refs (For availability see N74-14345 05-21)

The characteristics of pendulous gyro accelerometers and methods for conducting vertical acceleration tests are discussed. Mathematical models are developed to describe the primary elements of gyro accelerometer testing. Block diagrams of the test equipment and components are provided. The problems and procedures for conducting acceleration tests on a centrifuge and vibration tests are explained Author

N74-14348 Central Inertial Guidance Test Facility, Holloman AFB, N Mex
INERTIAL GUIDANCE SYSTEM CENTRIFUGE TESTING
Richard E Holdeman *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 15 p refs (For availability see N74-14345 05-21)

The development and characteristics of a centrifuge for testing inertial guidance systems are discussed. The subjects presented are (1) overall centrifuge capability, (2) test methods and sequence for testing a typical system, (3) instrumentation to monitor all signals for on-line data validation, (4) methods for computer data processing, and (5) test philosophy for evaluating component performance at the system level Author

N74-14349 Dornier-System G m b H, Friedrichshafen (West Germany)
TESTING OF AN ATTITUDE CONTROL UNIT FOR SOUNDING ROCKETS
Hartmut Siemann *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 8 p (For availability see N74-14345 05-21)

After a general view of the structure of an attitude control unit for sounding rockets a short description of the equipment available for the test of attitude control systems is given. On this basis a test philosophy is shown which allows a thorough testing of the attitude control unit at optimal costs. This can be done by a test program which examines every phase of the attitude control maneuver completely but without redundancy. Within this scope also environmental tests are dealt with. In the following some practical guidelines for preparation and execution of the tests are given, whereby the engagement of the customer plays a significant role. Author

N74-14350 Central Inertial Guidance Test Facility, Holloman AFB, N Mex
LABORATORY EVALUATION OF ELECTRO-OPTICALLY AIDED SPACE NAVIGATION SYSTEMS
Walter G Peterson *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 10 p refs (For availability see N74-14345 05-21)

A key step in any development program is the laboratory testing which provides a means of demonstrating the design concept and hardware performance. The success of this testing is dependent upon both laboratory accuracy and the faithfulness with which the systems' operational environment is duplicated within the laboratory. The greatly increased accuracy and complexity of electro-optically aided space navigation systems that are currently being developed, force the test engineer to devise new test methods in order to insure the validity of his results. This paper seeks to explain the approach that the Central Inertial Guidance Test Facility (CIGTF) is pursuing to meet this challenge. It discusses the way past systems have been tested and the methodology which will be used to evaluate future ones Author

N74-14351 Elektronik-System G m b H, Munich (West Germany)
TRENDS TOWARDS STANDARDIZED SOFTWARE AND HARDWARE FOR TEST SYSTEMS
B Eichenauer, M Mall and G Schweizer (Dornier-System G m b H) *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 20 p refs (For availability see N74-14345 05-21)

The use of automatic test equipment for check-out of aircraft before flight is discussed. A check-out system comprises an equipment to stimulate the system to be tested with defined test signals, measuring units, the interconnection system for the connection of all parts with the required test signals and measuring units, the process computer with the interface unit and input/output peripherals. There is a requirement for a variety of different stimuli and measuring units. Examples are ac and dc test signal sources, hydraulic transducers, mechanical transducers, instruments measuring current voltage, power, pressure, rotations. The required software is as important for the operation of a check out system as the hardware itself. The test procedures for the specific

system to be tested, the specification for the stimuli and the measuring units to be applied and the basic software for the computer and the process peripherals as well as the user program for the specific check-out equipment and the system to be tested are all parts of the software complex Author

N74-14352 Royal Aircraft Establishment, Farnborough (England)

AIRCRAFT INERTIAL SYSTEM TESTING AND EVALUATION IN THE UNITED KINGDOM

R F Stokes and S G Smith *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 49 p (For availability see N74-14345 05-21)

Internal system testing by Government Departments in the United Kingdom is undertaken by two Establishments - RAE Farnborough and A and AEE Boscombe Down For historical reasons most flying is done at A and AEE where a fully instrumented aircraft has been provided for precise navigation trials but the methods used are largely derived at RAE Details of the reference equipment available, its advantages and drawbacks, are given together with a description of the methods used to obtain a high quality, world-wide position and velocity reference Various methods of obtaining statistical performance parameters are discussed and their consistency is demonstrated The problems of performance diagnosis are illustrated with a worked example which also shows the use of a digital mathematical model of an IN system Some ideas on a possible new approach to inertial system testing are also given Author

N74-14353 Central Inertial Guidance Test Facility, Holloman AFB, N Mex

AIRCRAFT NAVIGATION SYSTEMS TESTING WITH A HIGH PRECISION REFERENCE

Melvin Birnbaum *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 11 p refs (For availability see N74-14345 05-21)

The development and characteristics of an aircraft test bed and a Completely Integrated Reference Instrumentation System (CIRIS) are described The system uses a display system with alphanumeric and graphic representation to provide indications of system operation The components of the system are illustrated and procedures for conducting the tests are analyzed Author

N74-14354 Central Inertial Guidance Test Facility, Holloman AFB N Mex

INERTIAL GUIDANCE SYSTEM SLED TESTING

G R Mozer *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 31 p refs (For availability see N74-14345 05-21)

The techniques used for precision sled testing of inertial and terminal guidance systems and components under high sustained linear accelerations with superimposed vibration on the Holloman fifty-thousand foot high speed rocket sled test track are discussed This track is instrumented with a precision position and time measuring system which measures the sled velocity to better than 0.02 feet/second Sledborne magnetic tape recorders and radio frequency (RF) telemetry are used to obtain data Time digitization of guidance system data for automatic computer processing is utilized Strapped-down and gimballed systems have been tested Accelerometers are tested in system configuration by installing them on a modified inertial platform Static calibration of accelerometer bias and scale factor, gyro drift coefficients, and inertial component non-orthogonality measurements are made between sled runs Accelerometer error models include terms which are a function of steady state acceleration inputs and dynamic acceleration sensitive terms Propagation of individual error sources, as a function of acceleration profile is examined Author

N74-14355 Thomson-CSF, Bagneux (France)

ROLE OF SIMULATIONS IN THE STUDY AND DEVELOPMENT OF THE CROTALE SYSTEM

G Paretti *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 21 p In FRENCH and ENGLISH (For availability see N74-14345 05-21)

After a general description of the CROTALE Weapon System, the main stages of the technical program development are indicated Then the role of simulations is discussed in further detail and the methodology of their use, on several levels, is stressed Attention is drawn to the basic character of a constant adjustment of simulations to experimental results Finally, an application of methodology is illustrated by a practical example, and simulation results are compared to test results Author

N74-14356 Central Inertial Guidance Test Facility, Holloman AFB, N Mex

TERMINAL GUIDANCE SYSTEM TESTING

Felix E Morgan *In* AGARD Testing Philosophy and Methods of Guidance and Control Systems and Subsystems Oct 1973 21 p ref (For availability see N74-14345 05-21)

Through the proper combination of complementary non-destructive tests and verification by a limited number of live firings, it is now possible to increase the test cost effectiveness (test validity divided by test cost) for terminally guided weapon systems These non-destructive tests are conducted under an 'integrated test' concept This concept dictates complementary tests in varied test arenas each providing some benefit not available in the others The results of all these non-destructive tests are then incorporated into a guidance performance propagation computer program to arrive at 'guidance only' total system performance The validity of the performance propagation for the particular system under test may then be verified by a limited number of live launches These valid guidance performance indicators can then be combined with non-guidance performance data to predict total weapon system effectiveness over a wider realm of launch parameters This can also be done at a lower cost than would have been possible utilizing only a large number of live launches The Guidance Test Division at Holloman AFB, New Mexico, is conducting such integrated tests This paper presents the detailed descriptions of the test facilities, test methods, and data reduction techniques required to arrive at the performance indicators inputs to the guidance performance propagation computer program Author

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22 NUCLEAR ENGINEERING

Includes nuclear reactors and nuclear heat sources used for propulsion and auxiliary power. For basic research see 24 Physics, Atomic, Molecular, and Nuclear. For related information see also 03 Auxiliary Systems, and 28 Propulsion Systems.

No abstracts in this subject category

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23 PHYSICS, GENERAL

Includes acoustics, cryogenics, mechanics, and optics. For astrophysics see 30 Space Sciences. For geophysics and related information see also 13 Geophysics, 20 Meteorology, and 29 Space Radiation.

N73-33619# Advisory Group for Aerospace Research and Development, Paris (France)
OPTICS OF THE SEA (INTERFACE AND IN-WATER TRANSMISSION AND IMAGING)
Aug 1973 431 p In ENGLISH, partly in FRENCH
(AGARD-LS-61) Avail NTIS HC $23.75
The proceedings of a conference on the optical properties of the sea are reported. The subjects discussed include the following (1) reflection and refraction of light at the sea surface, (2) refractive index fluctuations in sea water, (3) the theory of small angle scattering, (4) underwater visibility and imaging, (5) sources of light for underwater illumination, (6) long range vision techniques, and (7) spatial filtering and image restoration. For individual titles, see N73-33620 through N73-33638

N73-33620 Centre National d'Etudes des Telecommunications, Issy-les-Moulineaux (France) Div des Previsions Ionospheriques
INTRODUCTION TO THE ELECTROMAGNETISM OF THE SEA [INTRODUCTION A L'ELECTROMAGNETISME DES MERS]
P Halley *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 38 p refs In FRENCH (For availability see N73-33619 24-23)
The Debye theory of polarization of liquids was used to calculate real permittivity and conductivity of the sea. Also, visible light temperature measurements were used to observe superficial temperature and chemical composition of the sea surface. The effects of surface emissivity, reflection, and refraction are discussed Transl by E H W

N73-33621 Institute of Physical Oceanography, Copenhagen (Denmark)
RADIANCE DISTRIBUTION BELOW THE SEA SURFACE
Kjell Nygard *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 22 p refs (For availability see N73-33619 24-23)
Radiance distribution as a function of depth are the most basic radiometric quantities for describing the structure of the solar and global field of radiation in the upper layers of the sea. Immediately below the sea surface the radiance distribution is chiefly determined by the radiance distribution above the surface and by the reflecting and refracting properties of the air - water interface. Through the processes of absorption and scattering by the water itself and by dissolved and suspended matter the initial radiance distribution is progressively changed with increasing depth. A survey is given of concepts of inherent and apparent optical properties and simple models describing their interrelations and relations to the radiance distribution through the classical time-independent equation of radiative transfer are presented. Some experimental data are presented and discussed. A brief account of the polarization of the underwater light field is given Author

N73-33622 Centre de Recherches Oceanographiques, Villefranche-sur-Mer (France) Lab d'Oceanographie Physique
BRIEF ON THE THEORIES OF RADIATIVE TRANSFER APPLICATION TO PROPAGATION IN THE SEA [APERCU SUR LES THEORIES OU TRANSFERT RADIATIF APPLICABLES A LA PROPAGATION DANS LA MER]
L Prieur and A Morel *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 25 p refs In FRENCH (For availability see N73-33619 24-23)
Several theories on the propagation of electromagnetic waves in sea water are briefly discussed. Data cover transfer equations, computer methods, spherical harmonics, asymptotic methods, and perturbation theory Transl by E H W

N73-33623 Paris Univ (France) Lab d'Oceanographie Physique
SOLAR ENERGY AND SEASONAL THERMOCLINE [ENERGIE SOLAIRE ET THERMOCLINE SAISONNIERE]
J P Bethoux and A Ivanoff *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 7 p refs In FRENCH (For availability see N73-33619 24-23)
Various factors affecting the seasonal thermocline of the sea are studied by marine photometry. Specifically, the effects of advection, vertical temperature profiles, energy absorption, mixing boundary layer, and marine currents are discussed Transl by E H W

N73-33624 Paris Univ (France) Lab d'Oceanographie Physique
PHYSICAL FACTORS, CHEMICAL AND BIOLOGICAL EFFECT OF THE PROPAGATION OF LIGHT IN SEA WATER
Alexandre Ivanoff *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 45 p refs In FRENCH (For availability see N73-33619 24-23)
Definitions are given of parameters pertinent to characterizing the optical properties of turbulent and pure sea water. Various other factors affecting the optical properties of sea water including materials suspended in the water, substances in solution and incidence of refraction are discussed. Data are also given on the spatial and temporal distribution of optical properties Transl by E H W

N73-33625 Tetra Tech Inc, Pasadena, Calif
REFRACTIVE INDEX FLUCTUATIONS IN SEA WATER
Henri Hodara *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 14 p refs (For availability see N73-33619 24-23)
Mathematical methods for predicting the effects of thermal and saline inhomogeneities on optical imaging systems are presented. Temperature and salinity variations cause corresponding fluctuations in the refractive index resulting in loss of resolution. Formulas are developed for the refractive index changes in terms of their gradient with respect to salinity and temperature. It is stated that a dual-scan system is fairly immune to temperature and slinity fluctuations Author

N73-33626 Oregon State Univ, Corvallis School of Oceanography
VARIATION OF OPTICAL SEA PARAMETERS WITH DEPTH
J Ronald V Zaneveld *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 22 p refs (For availability see N73-33619 24-23)
The depth dependence of light scattering and attenuation parameters in the ocean are discussed. The theoretical dependence of optical parameters on the concentration, size distribution and physical parameters of the particulate matter is discussed. A simple model for the depth dependence of particulate matter concentrations is presented. Results agree qualitatively with observed distributions. The interrelation of optical parameters, particle concentration, and hydrographic parameters as obtained from experimental observations in several areas is discussed Author

N73-33627 Centre de Recherches Oceanographiques, Villefranche-sur-Mer (France)
DIFFUSION OF LIGHT BY SEA WATER. EXPERIMENTAL RESULTS AND THEORETICAL APPROACH [DIFFUSION DE LA LUMIERE PAR LES EAUX DE MER. RESULTATS EXPERIMENTAUX ET APPROCHE THEORIQUE]
Andre Morel *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 76 p refs In FRENCH (For availability see N73-33619 24-23)
Several theories - Rayleigh, Rayleigh-Gans, and Mie used to calculate light propagation in sea water as a function of

absorption and diffusion are discussed The effects of polarization, polydispersed and spherical particles, and long wave radiation are also discussed Definitions of various parameters used and experimental results are given in an appendix Transl by E H W

N73-33628 Tetra Tech, Inc , Pasadena, Calif
THEORY OF SMALL ANGLE SCATTERING
Willard H Wells *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 19 p refs (For availability see N73-33619 24-23)

The fundamental description of light scattering by particles in sea water is presented The volume scattering function is defined as the amount of light scattered per meter into a differential solid angle in a given direction For multiple scattering a derived quantity called the point spread function is needed to describe the intensity blur distribution at a given range Numerical relationships are developed to show the effects of various parameters on visibility conditions Author

N73-33629 Tetra Tech, Inc , Pasadena, Calif
EXPERIMENTAL RESULTS OF SMALL ANGLE SCATTERING
Henri Hodara *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 17 p refs (For availability see N73-33619 24-23)

The characteristics of light scattering at large angles, small angles, and very small angles For each of the angular ranges, the relative contributions from refraction and diffraction are calculated It was determined that large angle scattering is mostly due to diffraction, while refraction is responsible at small angles The results of scattering measurements by point spread function and by modulation transfer function are presented Author

N73-33630 Tetra Tech Inc Pasadena Calif
FACTORS AFFECTING LONG RANGE VISION
Willard H Wells *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 10 p refs (For availability see N73-33619 24 23)

The various phenomena which affect long range underwater vision are discussed The most important factors are (1) decay of light in narrow and broad beams (2) light backscattered from particulate matter, (3) return light whose image information is scrambled by small angle scatter enroute to the detector (4) the statistics of detected photons and (5) signal to noise ratio criteria for imaging Mathematical models are presented to show the effects of the various factors Author

N73-33631 Tetra Tech, Inc , Pasadena Calif
CRITERIA FOR VISION RESOLUTION, SIGNAL-TO-NOISE RATIO CONTRAST
Henri Hodara *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 13 p refs (For availability see N73-33619 24-23)

The vision criteria of resolution, signal to noise ratio and contrast are discussed The concepts are applied to calculate the ultimate resolution of underwater imaging systems It is stated that a signal to noise ratio of five is sufficient to ensure image quality Mathematical models of the factors affecting underwater vision are developed Author

N73-33632 Tetra Tech Inc Pasadena Calif
MEDIUM AND SYSTEM TRANSFORM FUNCTIONS
Willard H Wells *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 16 p (For availability see N73 33619 24-23)

The application of Fourier techniques to calculate the spread of scattered light surrounding other distributions is discussed for cases of a circular spot, a beam with Gaussian profile and a linear stripe The quantities needed for round trip propagation from transmitter to receiver are defined A formula for particle backscattering is developed A table of blur and offset distributions and the related Fourier transforms and transfer functions is included Author

N73-33633 Tetra Tech, Inc , Pasadena, Calif
SOURCES: ARC, FLASH, INCANDESCENT AND LASER LAMPS
Henri Hodara and Willard H Wells *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 17 p refs (For availability see N73 33619 24-26)

The major classes of incoherent and coherent sources of light for underwater applications are discussed A performance comparison figure for lamps is developed based on the square root of the round trip light attenuation from lamp to camera taking into account the source, the medium, and the receiver spectral sensitivity It is stated that the selection of a lamp is dictated by efficiency In that respect, incoherent sources are superior to lasers for most underwater illumination applications Author

N73-33634 Tetra Tech, Inc , Pasadena, Calif
RECEIVERS: PHOTOELECTRIC AND PHOTOGRAPHIC DETECTORS
Henri Hodara and Willard H Wells *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 15 p (For availability see N73 33619 24-23)

A procedure for comparing photo electronic and photographic detectors is discussed The criterion is based on the product of the signal to noise ratio and the spatial bandwidth The subjects discussed are (1) fundamentals for comparing detector performance, (2) units for measuring resolution, (3) characteristics of photoelectronic image detectors, and (4) characteristics of photographic film used with photoelectronic equipment Author

N73-33635 RCA Service Co Inc , Patrick AFB Fla
UNDERWATER LENSES AND OPTICAL PORTS
Lawrence F Mertens *In* AGARD Optics in the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 25 p refs (For availability see N73 33619 24 23)

Basic theoretical and practical aspects of using lenses and ports in underwater imaging systems are reviewed Terminology is defined and formulas for estimating field of view distortion and other aberrations are presented Several types of optical systems for correcting aberrations are reviewed The depth of field and relative aperture are compared for several lens port combinations Applications of short focal length, long focal length, and supplementary lenses are reviewed Author

N73-33636 Tetra Tech, Inc Pasadena Calif
LONG RANGE VISION TECHNIQUES
Willard H Wells *In* AGARD Optics in the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 13 p refs (For availability see N73 33619 24 23)

Techniques for long range vision are discussed Two methods range gating and dual scan with parallax are described The treatment assumes unsaturated photoelectronic detectors that are limited by photon noise not contrast A range gated system with radar like pulses offers the ultimate solution for long range vision as far as eight attenuation lengths and beyond with badly degraded resolution The best alternative to range gating is a dual scan system in which the illuminator and receiver are separated for parallax The practical limit is about seven attenuation lengths unless range gating is added to eliminate luminance in nearby water Author

N73-33637 Tetra Tech Inc Pasadena Calif
SPATIAL FILTERING AND IMAGE RESTORATION
Henri Hodara *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug 1973 12 p (For availability see N73 33619 24 23)

The exponential dependence of the ocean transfer function on range and the application to image restoration are discussed An inverse filter to restore photographs of floodlit targets blurred by turbulence is described and the limitations are analyzed The resolution degradation caused by a mismatch between filter and medium transfer functions is calculated The signal to noise ratio required to achieve various restorations is analyzed Author

N73-33838 Terra Tech, inc., Pasadena, Calif.
FORTRAN ALGORITHMS FOR UNDERWATER OPTICS
Willard H. Wells *In* AGARD Optics of the Sea (Interface and In-Water Transmission and Imaging) Aug. 1973 17 p (For availability see N73-33819 24-23)

The application of FORTRAN algorithms for underwater optics is discussed. The functions performed by various subroutines are described. An example of a complete computer program is provided. The selected program has utility for fundamental studies of water properties. It accepts a number of point spread functions measured at different distances and computes the spatial frequency decay function from each of them. Author

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24 PHYSICS, ATOMIC, MOLECULAR, AND NUCLEAR

Includes atomic, molecular and nuclear physics. For applications see 22 Nuclear Engineering. For related information see also 29 Space Radiation.

No abstracts in this subject category

25 PHYSICS, PLASMA

Includes magnetohydrodynamics. For applications see 28 Propulsion Systems.

No abstracts in this subject category

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26 PHYSICS, SOLID-STATE

Includes semiconductor theory, and superconductivity. For applications see 16 Masers. For related information see also 10 Electronics.

No abstracts in this subject category.

27 PROPELLANTS

Includes fuels, igniters, and oxidizers. For basic research see 06 Chemistry, and 33 Thermodynamics and Combustion. For related information see also 28 Propulsion Systems.

N72-11668# Advisory Group for Aerospace Research and Development, Paris (France).
AIRCRAFT FUELS, LUBRICANTS, AND FIRE SAFETY
Aug 1971 401 p refs Presented at 37th Meeting of the AGARD Propulsion and Energetics Panel, The Hague, 10-14 May 1971
(AGARD-CP-84-71) Avail NTIS HC $6.00/MF $0.95

Papers are presented on aircraft fuels, their production analysis, and testing. Fuel handling, fuel and fire safety, and lubricants are also discussed, using impact tests and crash simulations. For individual titles, see N72-11669 through N72-11701

N72-11669# National Research Council of Canada, Ottawa (Ontario). Fuels and Lubricants Lab.
JET FUEL SPECIFICATIONS
L. Gardner and R. B. Whyte *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 11 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

Various military and civil jet fuel specifications are compared and their differences noted, particularly with reference to different types of additives which are used on a mandatory or optional basis. Specification test procedures and their importance in relation to limits are discussed and the increased complexity of quality control for jet fuel specifications is noted. Author

N72-11670# France. Service Technique de l'Aeronautique, Paris.
AERONAUTICAL SIGNIFICANCE OF POLYCYCLIC SATURATED HYDROCARBONS [INTERET AERONAUTIQUE DES HYDROCARBURES POLYCYCLIQUES SATURES]
G. Verdie *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 12 p refs In FRENCH (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

The range of an airplane depends on the amount of energy used. When reservoir capacity is too limited, it is possible to extend the range by using a higher energy fuel. In this sense, high energy polycyclic saturated hydrocarbons are possible fuels for supersonic aeronautics in the near future, especially since their thermal stability is superior to that of present fuels. Essential fuel characteristics are presented together with the results of experimentation. Industrial fabrication problems and future perspectives are considered. Transl. by K.P.D.

N72-11671# Shell Research, Ltd., Chester (England). Thornton Research Centre.
FUELS FOR SUPERSONIC AND HYPERSONIC AIRCRAFT
A. Lewis, H. Strawson, and J. G. Kirtley *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 12 p refs Sponsored in part by Min. of Aviation Supply (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

The first generation of supersonic aircraft is being designed to operate on existing kerosene-type fuels. The limitations of these fuels are reviewed and possibilities considered for propellants for higher-speed aircraft, serving the triple purpose of cooling the airframe, cooling engine components, and providing propulsive energy. Problems of vapor deposition in hot fuel systems are covered and the possibilities explored of increasing the cold-sink value of the fuel by precooling or by endothermic decomposition. The calorific values of different fuels and the importance of recombination of dissociated combustion products is stressed. Ways of speeding such recombination are indicated. Author

N72-11672# Shell Development Co., Emeryville, Calif.
COOLING OF ADVANCED ENGINES BY ENDOTHERMIC REACTIONS OF HYDROCARBON FUELS
L. E. Faith, G. H. Ackerman, and H. T. Henderson *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 8 p refs Sponsored by AFAPL (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

The fuel used in an engine is a convenient coolant, absorbing heat as sensible heat and latent heat of vaporization. Certain hydrocarbon fuels can furnish additional heat sink in the form of endothermic reactions. Possible endothermic reactions include thermal reactions such as cracking, and catalytic reactions such as dehydrogenation, dehydrocyclization, and depolymerization. Of these, the catalytic dehydrogenation of naphthenes to aromatics is the most promising type of reaction. For example, the dehydrogenation of methylcyclohexane over platinum/alumina catalyst furnishes a reaction heat sink of approximately 1000 Btu/lb fuel, which is slightly greater than the cooling capacity due solely to sensible heat and latent heat of vaporization. This reaction is very selective and proceeds rapidly to achieve high conversion of methylcyclohexane to toluene and hydrogen. The total heat sink for such a reaction system compares favorably with that of hydrogen when these heat sinks are normalized by the heat of combustion of the fuel. Author

N72-11673# Monsanto Research Corp., Dayton, Ohio.
APPLICATION OF ANALYTICAL TECHNIQUES FOR THE ANALYSIS OF ADDITIVES AND CONTAMINANTS IN ADVANCED HYDROCARBON FUELS
W. G. Scribner *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 7 p refs (See N72-11668 02-27)
(Contract F33615-69-C-1325)
Avail NTIS HC $6.00/MF $0.95

A rapid method based on a specific ion electrode technique was adapted and verified for the determination of micrograms/g quantities in fuel of a fluorine-containing additive. A measurement method for ng/g levels of lead in hydrocarbon fuels is described, and the noninterference of allowed fuel additives is demonstrated. Examples are also cited where polar compound contaminants at the microgram/g level were isolated and identified by a combination of column chromatography and infrared spectrophotometry. Various factors which must be considered in method adaptation are reviewed, and the need for close communication between the fuel handling engineer and the analyst to expedite the solution of fuel contamination problems is stressed. Author

N72-11674# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Munich (West Germany). Inst. fuer Flugtreib- und Schmierstoffe.
THE POSSIBILITIES OF ACTUALLY TESTING THE COMBUSTION CHARACTERISTICS OF AVIATION FUELS WITH APPROPRIATE EQUIPMENT
H. Gemperlein *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 11 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

Small-scale combustion chamber rigs are described, with which combustion characteristics of aviation fuels are being tested. The relationship of the chemical constitution of the fuels and their chemical-physical properties, and the processes during preparation and combustion of fuel is determined. Investigation is conducted at different air and fuel temperatures and at differently high pressures in the combustion chamber in a parallel flow. Temporally consecutive processes during fuel preparation and combustion may also be specially separated and thereby provide for a measurement with customary probes as well as spectroscopic methods. Author

N72-11675# Pisa Univ. (Italy). Lab. Prove Combustibili.
LOW EMISSION FUELS AND DEVICES FOR AVIATION ENGINES
G. Nardi *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 13 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

Reduction of harmful emissions of turbine engine exhaust system is reviewed. The type of fuel used, combustion chambers, and operating conditions of combustors are also investigated. Author

N72-11676# National Research Council of Canada, Ottawa (Ontario) Fuels and Lubricants Lab
FUEL CLEANLINESS
L Gardner In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 13 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95
Dual purpose filter/separators were developed which could remove both dirt and water. Improvements in the performance of filter/separators was achieved by compliance with increasingly severe specifications. Methods of determining undissolved water and dirt in fuel and their development both for filter/separator testing and field use are discussed. Fuel contamination by microorganisms and surfactants has led to serious cases of aircraft corrosion and filter plugging. Measures to control or eliminate these two contaminants are discussed. Author

N72-11677# Lucas Gas Turbine Equipment, Ltd, Burnley (England)
FUEL RELATED PROBLEMS IN AIRCRAFT FUEL SYSTEMS
S L Forgham and R G Beckett In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 14 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95
Aircraft fuel problems are discussed, emphasizing problems associated with hydrogen treated fuels. Some of the problems were overcome by fuel system design modification, and other changes are reviewed which were instituted by refinery industries. Research on fuel sealing is also described. J.A.M.

N72-11678# BP Trading Ltd, London (England)
AIRCRAFT FUELLING OPERATIONS AND QUALITY CONTROL
G R Parker In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 12 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95
Aviation fuelling facilities and the fuelling operation are described. Comments on the types of aircraft are restricted to those aspects directly affecting fuelling. Author

N72-11679# Esso Development Co, Ltd, Abingdon (England) Research Centre
AVIATION FUEL LUBRICITY
R A Vere In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 13 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95
A laboratory test rig was developed to evaluate European jet fuels with regard to lubricity. This has shown differences in the lubricity levels of different fuels. Active lubricity agents were identified as fully saturated heterocyclic compounds and polynuclear aromatics. The addition of a surface active additive such as a corrosion inhibitor also significantly improve lubricity but can incur conductivity problems in the field due to its synergistic effects with antistatic additive. The feasibility of a fuel lubricity test by chemical, physical or mechanical techniques are being studied. Author

N72-11680# Applied Physics Lab, Johns Hopkins Univ, Silver Spring, Md
FLAME INHIBITION CHEMISTRY
R M Fristrom and R F Sawyer In AGARD Aircraft Fuels, Lubricants, and Fire Safety refs (See N72-11668 02-27) (Grant NSF GI-12)
Avail NTIS HC $6.00/MF $0.95
Techniques involving diverse mechanisms are employed in extinguishing flames and fires. Mechanisms were divided into two broad categories: (1) physical mechanisms when mechanical or thermal effects are dominant, and (2) chemical mechanisms when chemical effects are involved. Flame extinguishment viewed from the standpoint of the effects on the elementary reaction processes is reviewed. A simplified hydrogen-oxygen flame chemistry is used as an illustration. The complications introduced by chemical inhibition are pointed out. The chemical kinetic information in the area of hydrogen atom scavenging and oxygen flame radical recombination is surveyed. Author

N72-11681# Air Force Systems Command, Wright-Patterson AFB, Ohio Aero Propulsion Lab
FLAMMABILITY PROPERTIES OF JET FUELS AND TECHNIQUES FOR FIRE AND EXPLOSION SUPPRESSION
B P Botteri In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 11 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95
Results of investigative efforts to establish the practical flammability envelopes and associated combustion damage potential for conventional jet fuels such as JP-4, JP-8 (similar to JET A-1), and JP-5 under simulated hostile operating environment conditions are presented. Testing included liquid-space gunfire hits to assess external fire hazard and vertical (liquid to vapor) firing trajectories to determine explosion hazard associated with projectile-induced fuel sprays and mists. All tests were performed in instrumented replica target tanks varying in volume from 15 to 90 gallons. Principal test variables were fuel temperature, pressure, fuel depth, external void space, and internal and external air flow. All tests were conducted utilizing 0.50-caliber armor piercing incendiary projectiles. These tests indicate a considerable extension in the flammability range of all fuels compared to the equilibrium flammability limit values which are commonly utilized for fire safety analysis. In view of the fire and explosion potential exhibited by all conventional jet fuels, additional measures must be employed to achieve an effective fire-protection capability. Progress in the use of reticulated polyurethane foam, halogenated hydrocarbon chemical extinguishers and other fuel-tank-inerting techniques is also reviewed. Author

N72-11682# Institut Francais du Petrole, Paris (France)
INFLUENCE OF MOLECULAR STRUCTURE ON SELF-IGNITION PROPERTIES OF HYDROCARBONS [INFLUENCE DE LA STRUCTURE MOLECULAIRE SUR CERTAINES PROPRIETES D'AUTO-INFLAMMATION DES HYDROCARBURES]
G DeSoete In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 12 p refs In FRENCH; ENGLISH summary (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95
The adiabatic compression method was used to determine delays in self-ignition by different hydrocarbon-air mixtures as a function of pressure and temperature. A comparison of experimental results makes it possible to evaluate the effect of some special molecular structure characteristics on the overall activation energy. In particular, the presence of ternary carbon atoms and double carbon-carbon bonds results in a decrease in this activation energy. Tests made with mixtures of two different hydrocarbons show that the kinetic parameters controlling the dependency of ignition delay on temperature vary in such a way that the delay with a mixture tends to approach that of the pure component having the shortest delay at the temperature considered. This phenomenon was found to be all the greater as the relative concentration of this component in the binary mixture is higher. Author

N72-11683# Princeton Univ, N.J. Guggenheim Lab
IGNITION OF FUELS BY A HOT PROJECTILE
O P Sharma and W A Sirignano In AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 18 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95
Theoretical investigations were performed by approximating (1) the flow at the forward end of the projectile to a stagnation flow towards a hot axisymmetric body, (2) the flow over its surface to a laminar flow over a hot plate, and (3) the flow in the wake of the projectile to a plane laminar mixing of the cold unreacted mixture with the hot combustion products. After the premixed mixture is exhausted there is a possibility of ignition of unmixed reactants by the hot inert products which are left behind and are sandwiched between the oxidizer and the fuel. A theoretical analysis for the ignition delay time as a function of the temperature and the width of the hot gas region is also presented. Author

N72-11684# Centre National de la Recherche Scientifique Paris (France)

INFLUENCE OF PROMOTERS (FREE RADICALS) AND INHIBITORS ON DIFFUSION FLAMES [INFLUENCE DES PROMOTEURS (RADICAUX LIBRES) ET DES INHIBITEURS SUR LES FLAMMES DE DIFFUSION]

J. Combourieu, C. Falinower, and G. Denis *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 11 p refs In FRENCH; ENGLISH summary (See N72-11668 02-27)

Avail NTIS HC $6.00/MF $0.95

The laminar diffusion flames of acetylene with molecular oxygen and with molecular oxygen partly dissociated were stabilized in a low pressure vessel. A partial dissociation of O2 into O atoms was produced by a powerful microwave discharge. Concentration profiles of stable species were determined with a microprobe and a mass spectrometer. Temperature profiles were obtained from a silica-coated thermocouple. The intensities of spectral emission were recorded for excited species with a spectrophotometer. The complex structure of these diffusion flames shows that the combustion of C2H2 involves several steps. The partial dissociation of O2 emphasizes the significant role played by O atoms in the combustion of C2H2. The influence of halogenated inhibitors is very different according to the kind of inhibitor and whether it is added to the oxidizer or the fuel. Author

N72-11685# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany) Inst. fuer Luftstrahlantriebe

CONTRIBUTION TO THE SELECTION OF FIRE EXTINGUISHING SYSTEMS AND AGENTS FOR AIRCRAFT FIRES

R. Fiala *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 10 p refs (See N72-11668 02-27)

Avail NTIS HC $6.00/MF $0.95

A fire extinguishing-system in aircraft is described which uses the exhaust gases of a solid-propellant gas generator to pressurize the extinguisher bottle. The extinguishing efficiency of this hot-bottle-system is compared with that of the current extinguishing system. The amount of agent which is necessary to extinguish a diffusion flame was measured for a number of halons, dry powders, and mixtures of dry powders and halons. The ability of agents to prevent reignition of the extinguished fuel surface by hot parts was also tested. Author

N72-11686# Shell Research, Ltd., Chester (England)

ELECTROSTATIC CHARGING IN THE HANDLING OF AVIATION FUELS

H. Strawson and A. Lewis *In* AGARD Aircraft Fuels, Lubricants and Fire Safety Aug 1971 11 p refs (See N72-11668 02-27)

Avail NTIS HC $6.00/MF $0.95

Electrostatic charging of the fuel during fueling can result in the possibility of incendiary sparking in aircraft tanks; some of the more recent experimental results on the different phases of this process are presented. These results confirm that, in the absence of special precautions, discharges creating a tank explosion hazard can exist during aircraft refueling in certain circumstances. Unless the fuel conductivity is controlled, however, these hazardous circumstances cannot be precisely predicted. The use of a static dissipator additive eliminates the hazard. Methods of introducing the additive and of maintaining the correct conductivity during fuel distribution are discussed, as well as possible side effects and interactions with other fuel additives. On the basis of world-wide airline use over many years supported by many laboratory tests, it is concluded that the additive provides a safe, simple and trouble-free solution to the problem. Author

N72-11687# National Aviation Facilities Experimental Center, Atlantic City, N.J.

CRASH SAFE TURBINE FUEL DEVELOPMENT BY THE FEDERAL AVIATION ADMINISTRATION, 1964 - 1970

R. A. Russel, Jr. *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 10 p refs (See N72-11668 02-27)

Avail NTIS HC $6.00/MF $0.95

Crash-safe fuel program, a segment of a primary mission to improve the overall crashworthiness of aircraft, is discussed. The reduction of the probability and severity of fire during aircraft ground crash situations is also examined. Author

N72-11688# Southwest Research Inst., San Antonio, Tex. Army Fuels and Lubricants Research Lab.

EMULSIFIED FUELS AND AIRCRAFT SAFETY

W. D. Weatherford, Jr. and F. W. Schaekel (Army Coating and Chem. Lab.) *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 12 p refs (See N72-11668 02-27)

(Contracts DAAD05-70-C-0250; DAAJ02-69-C-0030)

Avail NTIS HC $6.00/MF $0.95

Research and development program aimed at improving the post-crash fire safety of helicopter turbine-engine fuels is reviewed. Primary emphasis was placed on high-internal-phase-ratio aqueous emulsions. Interrelations among rheological and physical properties, composition, and fire safety characteristics of various fuel formulations are discussed. Implications of these results on the total safety envelope of rotary wing aircraft are examined. Author

N72-11689# Bureau of Mines, Pittsburgh, Pa. Mining and Safety Research Center

FIRE HAZARD EVALUATION OF THICKENED AIRCRAFT FUELS

J. M. Kuchta, J. N. Murphy, A. L. Furno, and A. Bartkowiak *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 11 p refs (See N72-11668 02-27)

Avail NTIS HC $6.00/MF $0.95

Various gelled or emulsified fuels were proposed for reducing the aircraft crash-fire hazard. Results are presented from bench-scale tests for screening the fuels and from large-scale drop tests for evaluating their fire hazard under simulated crash conditions. Jet A and Jet B type thickened fuels were investigated. Their minimum autoignition temperatures and burning rates varied little, whereas their flash points, volatility rates, self-spread rates, and flame spread rates varied noticeably with either the base fuel or thickening agent composition; minimum ignition energies are also compared for liquid sprays. The performance of the thickened fuels, particularly Jet B emulsions, was not very promising under impact conditions. In fuel drops made from a 150-ft three-tower facility, the fireball size and radiation intensity varied with impact velocity, impact angle, and type of fuel container. Author

N72-11690# Royal Aircraft Establishment, Farnborough (England) Engineering Physics Dept.

FIRE AND EXPLOSION PROTECTION OF FUEL TANK ULLAGE

J. A. MacDonald and H. W. G. Wyeth *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 7 p refs (See N72-11668 02-27)

Avail NTIS HC $6.00/MF $0.95

The conditions that can lead to an explosion within aircraft fuel tank ullages are examined, and the need for protection systems is reviewed. Principles employed in providing the desired degree of protection are outlined, such as oxygen reduction, vapor or mist inerting, and plastic foam fillers. Comparisons were made between the various sytems and their relative merits were also discussed. It is concluded that plastic foam is an effective system provided that the material is compatible with the environment. Liquid nitrogen is also attractive from the weight aspect but could impose logistic problems. Author

N72-11691# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany) Inst. fuer Luftstrahlantriebe

INVESTIGATION OF FIRE EXTINGUISHING POWDERS BY MEANS OF A NEW MEASURING PROCEDURE
R Fiala and G Winterfeld *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug. 1971 12 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

In order to optimise fire extinguishing systems it is necessary to compare the extinguishing efficiency of solid and gaseous (or liquid) extinguishing agents. A measuring procedure is described which allows this direct comparison. It makes use of the relationship between the maximum flow velocity at the burning limit of a flame-holder stabilized flame and the laminar burning velocity of the fuel-air-mixture which is given by DAMKOHLER's first number. Comparative results achieved with this procedure for several fire extinguishing agents are given
Author

N72-11692# Royal Aircraft Establishment, Farnborough (England) Materials Dept
SIMULATED CRASH TESTS AS A MEANS OF RATING AIRCRAFT SAFETY FUELS
R E Miller and S P Wilford *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 13 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

Two tests are described for assessing the fire resistance of Avtur containing polymeric additives which reduce its ability to form flammable mists. In the standard test a tank containing ten or twenty gallons of fuel is propelled on a rocket sled at speeds of 114 or 188 ft/sec and decelerated after contact with an aircraft arrester wire. Fuel is allowed to spill from a slit in the tank onto a series of ignition sources. In the run on test the tank travels at speeds up to 240 ft/sec past a series of ignition sources while spilling fuel from a slit on the leading edge. The velocities of spilled fuel relative to the surrounding air which occur in these tests are shown to be comparable to those occurring during survivable aircraft crashes
Author

N72-11693# Applied Physics Lab, Johns Hopkins Univ, Silver Spring, Md
SURFACE ACTIVE CONSIDERATIONS IN FUEL FIRES
Richard L Tuve *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 4 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

The problem of efficient extinguishment of fires in burning fuels is dealt with. The use of low density water, in the form of foam is considered as a means of achieving some solutions to the mechanical and physical needs involved. Emphasis is placed on the utilization of fluorocarbon surfactants which combine foam requirements and fuel-water interfacial activities benefitting fire extinguishing action. Recent development and test of these materials are discussed
D L G

N72-11694*# General Electric Co, Cincinnati, Ohio Material and Process Technology Labs
LUBRICANT AND FUEL INTERACTIONS IN ADVANCED AIRCRAFT GAS TURBINES
E N Bamberger, D B Hester, and M W Shayeson *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 12 p refs Sponsored in part by NASA AFAPL and FAA (See N72-11668 02-27)
(NASA-CR-122842) Avail NTIS CSCL 11H

The interactions and relationships between lubricants and fuels and their properties as related to systems in aircraft gas turbine engines are dealt with. Three areas of recent research are cited to illustrate the impact of lubricant and fuels capabilities on modern engines: (1) a study of the influence of lubricant properties on turbine engine design characteristics especially with regard to high speed supersonic applications, (2) the development of a precise and meaningful test procedure for measuring the thermal stability of kerosene fuels, and (3) the evaluation of advanced high temperature lubricating fluids and their effects on engine bearing performance
Author

N72-11695# Esso Development Co Ltd Abingdon (England) Research Centre
STABILITY OF SYNTHETIC AVIATION GAS TURBINE LUBRICANTS AT HIGH TEMPERATURES
R Robson *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 8 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

The development of ester based synthetic aviation lubricants over the last 20 years is reviewed. Methods of assessing the high temperature stability of the lubricants are described and the main factors controlling stability are discussed. The suitability of alternative synthetic fluids is considered
Author

N72-11696# Institut Francais de Petrole, Grenoble (France)
SYNTHESIS AND PROPERTIES OF ESTERS OF TETRAMETHYL-2,2,7,7 OCTANE DIOL-1,8 [LES ESTERS DU TETRA METHYL-2,2,7,7 OCTANE DIOL-1,8 SYNTHESE ET PROPRIETES]
P Badague, B Sillion, and G DeGaudemaris *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 8 p refs In FRENCH (See N72-11668 02-27)
Avail NTIS HC $6.00/MF $0.95

A diol of the neopentylic type was obtained by a series of simple reactions proceeding from cyano-4 dimethyl-2,2 butyraldehyde. Esters of linear acids and alpha alpha prime dimethylated acids were synthesized. Their physical characteristics were determined. Thermal stability and resistance to hydrolysis and oxidation in the presence of metals were examined
Transl by K P D

N72-11697# Rolls-Royce, Ltd, Bristol (England) Engine Div
LUBRICANT EXPERIENCE AND DUTIES IN A CIVIL SUPERSONIC GAS TURBINE ENGINE
E W Doherty *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 12 p ref (See N72-11668 02-27)
Avail NTIS HC $6.00 MF $0.95

A description is presented of the Olympus 593 Mk 602 oil system generally, and particular reference is given to the design precautions against the oil fire risk, the use of oil in engine failure warning devices, and in engine health monitoring. Current engine test and flight experience with the lubricant is covered especially with respect to oil consumption, high temperature breakdown areas, prevention of oil carbon formation, mixing of lubricants brands, erosion corrosion effects, and policy in approval processes of lubricants
Author

N72-11698# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Munich (West Germany) Inst fuer Flugtreib- und Schmierstoffe
EARLY STAGE DETECTION OF OIL CHANGES IN AIRCRAFT ENGINES
E Jantzen *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 13 p refs (See N72-11668 02-27)
Avail NTIS HC $6.00 MF $0.95

Potential analytical methods for detection of changes in aircraft turbine oils in the early state are reported and their possible advantages and disadvantages as well as their informative value are discussed. In addition the cause of premature or sudden oil changes in an aircraft engine is investigated. A test rig for simulating such oil changes and the results obtained are discussed. In conclusion the possibilities of a simultaneous wear control of aircraft turbine oils are briefly explained
Author

N72-11699# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
THERMAL STABILITY OF A TRI-METHYL-PROPANE ESTER BASED LUBRICATING OIL [CHAMP D'APPLICATIONS D'UNE HUILE BASEE SUR UN ESTER DU TRIMETHYLOL-PROPANE]
F Reynaud *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 22 p refs In FRENCH, ENGLISH summary (See N72-11668 02-27)

Avail NTIS HC $6 00 MF $0 95

Following a general discussion on the increased performance requirements of lubricating oils made mandatory by increased operating temperatures, the operational possibilities of a tri-methyl-propane ester in two domains of application are described. The first area of application considered was a conventional circuit with oil temperature around 230 C. By adding appropriate additives, a formula was developed with very satisfactory characteristics, particularly in regard to oxidation corrosion. The second area of usage studied was at the 380 C level. The formula appeared not to be well adapted to the new conditions, with some additions losing their efficiency. However the ester remained valid as a base. DLG

N72-11700# Air Force Systems Command, Wright-Patterson AFB, Ohio. Aero Propulsion Lab.

SOLID LUBRICATION FOR AERO PROPULSION SYSTEMS

M. R. Chasman *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 13 p refs (See N72-11688 02-27)

Avail NTIS HC $6 00 MF $0 95

Self contained solid lubricated bearings were developed for application to current and future aircraft propulsion and power generation equipment. The capability for long life operation over a wide range of temperatures in an air environment was demonstrated. The approach was to use solid lubricants as a sacrificial retainer material in 20 mm and 35 mm bore bearings. In some cases stainless steel and titanium shrouds were used to provide added strength to the solid lubricant retainers. Lubricants were selected based on their strength, oxidation, friction, and wear properties. It was necessary to deviate from oil and grease lubricated bearing design to achieve acceptable life. Bearing clearance, number of balls, retainer to land clearance and ball pocket size were optimized. Hundreds and in some cases thousands, of hours of life were demonstrated. Author

N72-11701# BP Benzin und Petroleum AG, Munich (West Germany)

SYNTHETIC LUBRICANTS FOR SUPERSONIC AIRCRAFT

H.-D. Corn *In* AGARD Aircraft Fuels, Lubricants, and Fire Safety Aug 1971 8 p (See N72-11688 02-27)

Avail NTIS HC $6 00 MF $0 95

Classifications and characteristics of synthetic aero turbine oils are reviewed. These oils are classified as type 1 and type 2 lubricants. The type 1 lubricants are defined as blends of a diester basestock and an additive package. Although still being used in jet engines, their use in advanced turbines is considered to be limited by marginal resistance to thermal and oxidative stress. Type 2 lubricants, developed to meet the increased requirements of more sophisticated aircraft, are defined as blends of a hindered tri- or tetraester basestock and an additive package. The burden placed on these lubricants by sustained flight at supersonic speeds is discussed, and the development of an advance complex ester lubricant with a novel additive package for Mach 2 + engines is reported. DLG

N72-27811# National Research Council of Canada, Ottawa (Ontario). Fuels and Lubricants Lab.

TECHNICAL EVALUATION REPORT ON PROPULSION AND ENERGETICS PANEL 37TH MEETING ON AIRCRAFT FUELS, LUBRICANTS, AND FIRE SAFETY

R. B. Whyte and L. Gardner Paris AGARD May 1972 9 p refs

(AGARD AR 44) Avail NTIS HC $3 00

The discussions which took place at a meeting on aircraft fuels, lubricants and fire safety are presented. The subjects discussed are (1) fuels production analysis and testing (2) fuel handling (3) lubricants and (4) fire safety research. It was concluded that from an operational aspect the fuels and lubricants used for aircraft engines are satisfactory up to at least Mach 2.2. It was recommended that additional developments be undertaken to provide refueling systems capable of dealing with larger volumes of fuel at higher rates of flow than exist in present equipment. Author

28 PROPULSION SYSTEMS

Includes air breathing, electric, liquid, solid, and magnetohydrodynamic propulsion. For nuclear propulsion see 22 Nuclear Engineering. For basic research see 23 Physics, General, and 33 Thermodynamics and Combustion. For applications see 31 Space Vehicles. For related information see also 27 Propellants.

N71-17372# Advisory Group for Aerospace Research and Development, Paris (France)

HIGH TEMPERATURE TURBINES

Jan 1971 587 p refs Presented at the 36th Meeting of the AGARD Propulsion and Energetics Panel, Florence, 21-25 Sep 1970

(AGARD-CP-73-71) Avail NTIS HC$6.00 MF$0.95

Cooling techniques for turbine blades of high temperature aeronautical gas turbine engines. Advanced cooling methods and the application of improved heat resistant materials are discussed. For individual titles, see N71-17373 through N71-17404.

N71-17373# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France)

HIGH ENTRY TEMPERATURE TURBINE ON TURBOREACTORS AND GAS TURBINES [DES HAUTES TEMPERATURES DEVANT TURBINE SUR TURBOREACTEURS ET TURBINES A GAZ]

P. Alesi *In* AGARD High Temp Turbines Jan 1971 14 p In FRENCH (See N71-17372 07-28)

Avail NTIS HC$6.00/MF$0.95

High entry temperatures for gas turbine engines decrease specific wear and always augment reduced pressures so that gas turbines can compete with Diesel engines in operational performance. Studies on turbocompressors with increased inlet temperatures showed that specific power in simple and double fluxes of moderate expansion increased and that all compressor double flux expansion rates were augmented threefold. Increased temperatures at turbine inlets augment compression and improve the efficiency of compression-diluting elements. Transl. by G.G.

N71-17374# National Gas Turbine Establishment, Pyestock (England)

HEAT TRANSFER CALCULATIONS FOR TURBINE BLADE DESIGN

J. Dunham and J. P. Edwards *In* AGARD High Temp Turbines Jan 1971 18 p refs (See N71-17372 07-28)

Avail NTIS HC$6.00/MF$0.95

The operating temperature of a cooled turbine blade depends on the heat transfer rate from the hot gas stream, the heat conduction within the metal, and the heat convection to the cooling air. Discussed are methods of calculating these factors, and their application to blade design. The effect of cooling on turbine performance is also considered. Author

N71-17375# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France)

TEMPERATURE DETERMINATIONS IN THE BLADES OF CONVECTION COOLED TURBINES [DETERMINATION DES TEMPERATURES DANS LES AUBES DES TURBINES REFROIDIES PAR CONVECTION]

G. Chiron *In* AGARD High Temp Turbines Jan 1971 13 p refs In FRENCH (See N71-17372 07-28)

Avail NTIS HC$6.00/MF$0.95

A mathematical method is presented for calculating the temperature distribution in a convectively cooled turbine blade by considering the temperature constraints imposed on blade life in the estimation. Comparison between experimental and theoretical results verify the validity of this method for short and median length operations. Transl. by G.G.

N71-17376# Rolls-Royce, Ltd., Bristol (England). Bristol Engine Div.

OLYMPUS 593 TURBINE COOLING

M. J. Holland *In* AGARD High Temp Turbines Jan 1971 21 p refs (See N71-17372 07-28)

Avail NTIS HC$6.00/MF$0.95

Turbine cooling effectiveness and efficiency are defined for subsequent use in descriptions of cooling performance. The factors affecting the choice of cooling design point and the sources of cooling air are discussed. In particular, the use of 5th stage (H.P. compressor air in place of compressor delivery air is shown to result in lower rotor blade temperatures for the H.P. turbine. The differing environments and requirements for turbine stator and rotor blades are discussed, together with the importance of combustion chamber outlet gas temperature profiles. The turbine rotor and stator blades are convection cooled and are fairly conventional. The evolution of the various blade cooling designs is described together with summaries of their cooling performance. Author

N71-17377# Sussex Univ., Brighton (England). School of Applied Sciences

HEAT TRANSFER INSTRUMENTATION

A. B. Turner *In* AGARD High Temp Turbines Jan 1971 18 p refs (See N71-17372 07-28)

Avail NTIS HC$6.00/MF$0.95

A brief review of heat transfer instrumentation with particular attention to the requirements of the gas turbine engineer is presented. The work is focused primarily on heat fluxmeters, recent developments in methods of temperature measurement and thermocouple installation errors. In this latter section a numerical procedure for the problem of sensors embedded in insulation channels is presented together with some correlations and predictions for typical examples in solid and porous surfaces. Author

N71-17378# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

HEAT FLUX MEASUREMENTS ON FIXED TURBINE BLADES [MESURES DE FLUX DE CHALEUR SUR AUBES FIXES DE TURBINES]

Jacques Michard *In* AGARD High Temp Turbines Jan 1971 9 p refs In FRENCH; ENGLISH Summary (See N71-17372 07-28)

Avail NTIS HC$6.00/MF$0.95

Experimental results obtained on a set-up including a moderately high temperature combustion chamber (1300 K) and two stages of fixed blades are presented. The first stage is used as a distributor, the other one turning the flow parallel to its upstream direction at the outlet. Heat transfer and local exchange coefficients obtained with an upstream Mach number of 0.2 and a Reynolds number of 25 000 per cm are analyzed. Author

N71-17379# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Luftsaugende Antriebe

TEMPERATURE MEASUREMENTS WITH THERMOCOUPLES INCLUDING ERRORS CAUSED BY CATALYTIC EFFECTS

P. Stottmann *In* AGARD High Temp Turbines Jan 1971 10 p refs (See N71-17372 07-28)

Avail NTIS HC$6.00/MF$0.95

Several methods for the temperature measurement in combustion gas are discussed, especially the influence with thermocouples. Corrections for compensation of the influences due to flow velocity, radiation and heat conduction are described. In case of using noble metal thermocouples the possible errors by catalytic effects are studied. Experimental results are presented which show the ignition of a fuel air mixture outside the boundary

layer of the probe initiated by the catalytic influence of the platinum surface The reproducible catalytic effects which initiate or force reactions in a gaseous fuel-air-mixture are dependent on the external flow conditions gas temperature gas velocity fuel-air-ratio and the distribution and evaporation of the fuel Coating the noble metal surfaces with Al_2O_3 avoids the catalytic effects Author

N71-17380# Von Karman Inst for Fluid Dynamics Rhode Saint-Genese (Belgium)

DESIGN OF SMALL DIMENSION TURBINE BLADE BY THEORETICAL ANALYSIS [DESSIN D'UNE AUBE DE TURBINE DE PETITE DIMENSION AU MOYEN DE PROCEDURES THEORIQUES]

C Loudet *In* AGARD High Temp Turbines Jan 1971 28 p refs In FRENCH ENGLISH Summary (See N71-17372 07-28)

Avail NTIS HC $6.00 MF $0.95

The method of blade boundary layer optimization due to Le Foll is used for the calculation of a small turbine blade in incompressible flow with Goldstein's method for the resolution of the inverse potential flow problem A blade with a cusped trailing edge has been calculated for the following flow conditions inlet angle 32 deg outlet angle 54.8 deg and Reynolds number based on the chord and outlet velocity This blade gives a theoretical loss coefficient based on the dynamic outlet pressure of 4.45% The calculated losses are in good agreement with the experimental results taking into account the fact that a truly two dimensional flow could not be obtained during the tests Author

N71-17381# United Aircraft of Canada Ltd Longueuil Quebec

AN EXPERIMENTAL COOLED RADIAL TURBINE

U Okapuu and G S Calvert Pratt and Whitney Aircraft West Palm Beach Fla *In* AGARD High Temp Turbines Jan 1971 12 p (See N71-17372 07-28)

Avail NTIS HC $6.00 MF $0.95

A cooled radial turbine suitable for compressor drive in a twin spool engine was designed and is at present undergoing experimental evaluation Assumed turbine design point conditions were 2300 degrees F inlet temperature 17.1/2 atmospheres inlet pressure 4.9 lbs sec mass flow rate 5.1:1 turbine pressure ratio 220 BTU lb enthalpy drop and a rotational speed of 67 000 rpm Turbine components are nickel alloy castings in which cooling air passages are incorporated The design features of the turbine and the results of thermal and stress analyses of its components are described Author

N71-17382# Motoren-und Turbinen-Union Muenchen G m b H (West Germany)

EFFUSION COOLING OF TURBINE BLADES

H Prechter A Schoenbeck and N Scholz *In* AGARD High Temp Turbines Jan 1971 14 p refs (See N71-17372 07-28)

Avail NTIS HC $6.00 MF $0.95

Theoretical and experimental investigations into the aerodynamic and thermodynamic performance of effusion cooled turbine blades are presented To estimate the aerodynamic and cooling performance an extensive computer programme has been worked out the physical background of which is described in this report Few available experimental test results are drawn on to back up the theoretical procedure Some parametric studies are presented showing the chord- and spanwise temperature distributions for an effusion cooled blade with different coolant flow distribution The cooling effectiveness is investigated for various parametric changes and compared with that of an internally cooled blade The aerodynamic behaviour reveals a considerable increase in profile loss coefficient of a porous turbine blade both with and without coolant effusion The effect on overall engine performance by using an effusion cooled high pressure turbine in a modern turbo jet engine is briefly discussed Author

N71-17383# Sussex Univ Brighton (England) School of Applied Sciences

TRANSPIRATION-COOLED TURBINES

F J Bayley and A B Turner *In* AGARD High Temp Turbines Jan 1971 16 p refs (See N71-17372 07-28)

Avail NTIS HC $6.00 MF $0.95

The steps in the development chain of air cooling for gas turbine components and transpiration cooling are described The three modes of heat transfer involved in transpiration cooling (gas side heat transfer coolant side heat transfer and interstitial heat transfer) are discussed separately Finally consideration is given to the practical problems of transpiration cooling in advanced gas turbines Author

N71-17384# Curtiss-Wright Corp Wood Ridge N J

EXPERIENCE WITH TRANSPIRATION COOLED BLADES

S Lombardo and S L Moskowitz Sucola di Guerra Aerea *In* AGARD High Temp Turbines Jan 1971 20 p refs (See N71-17372 07-28)

Avail NTIS HC $6.00 MF $0.95

The propulsion system requirements of advanced aircraft necessitate incorporation of significant technological advances in the state-of-the-art of major components in the engine These advances evolve from the use of advanced design concepts coupled with adequate testing to substantiate the performance and durability through component and full scale engine testing Achievement of high turbine inlet temperatures in turbine engines through the use of transpiration air cooled turbine blades is considered Briefly reviewed are the various transpiration air cooled turbine blades evaluated This evaluation includes blade design aspects modes of fabrication and materials of construction The results of component and full scale engine testing up to 3000 F (1650 C) are also presented Author

N71-17385# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

TURBINE COOLING ITS LIMITATIONS AND ITS FUTURE

Jack B Esgar *In* AGARD High Temp Turbines Jan 1971 25 p refs (See N71-17372 07-28)

(NASA-TM-X-66702) Avail NTIS CSCL 21E

The relative merits of convection transpiration and full coverage film cooling methods were analytically investigated for a turbine inlet temperatures from 2000 to 3500 F gas pressures from 5 to 40 atmospheres and cooling air temperatures from 600 to 1200 F Effects of wall thickness and material temperature were also investigated Transpiration or full coverage film cooling will probably be necessary to permit operation at local turbine inlet temperatures on the order of 3000 F and compressor pressure ratios of 20 or higher Full coverage film cooling is often superior to transpiration cooling because oxidation problems with transpiration cooled materials reduce allowable metal operating temperatures Increasing allowable metal temperature 100 F or reducing cooling air temperature 200 F can do more to improve convection cooling than is possible by improvements in current advanced state of the art convection cooled blade or vane design Author

N71-17386# General Electric Co Cincinnati Ohio

HIGH TEMPERATURE TURBINE DESIGN CONSIDERATIONS

S N Suciu *In* AGARD High Temp Turbines Jan 1971 29 p refs (See N71-17372 07-28)

Avail NTIS HC $6.00 MF $0.95

The major technological developments which have made possible the trend towards higher temperatures in modern aircraft gas turbine engines are discussed The relative importance of manufacturing processes material developments cooling techniques analytical design procedures rupture and cyclic life considerations and aerodynamic and mechanical design improvements are discussed along with illustrative examples and technical data The

need for a balanced design approach is stressed, and examples are given where trade offs can be made. It is noted that the advances in aircraft engines during the last 10 years have been based on the evolution of sound engineering principles, extensive component and engine development, and careful consideration of the operational requirements rather than a tremendous breakthrough or revolutionary concept in any one area. Author

N71-17387# Technische Hochschule Aachen (West Germany) Inst fuer Strahlantriebe

EXPERIMENTAL INVESTIGATION ON A SINGLE-STAGE AIR-COOLED GAS TURBINE

W Kuehl *In* AGARD High Temp Turbines Jan 1971 14 p refs (See N71-17372 07-28)

Avail NTIS HC $6.00/MF $0.95

Temperature measurements made within the convection air-cooled rotor blade of a gas turbine during operation cannot deliver complete information of the temperature field, for the number of measuring points is limited by technical considerations. But by using the analogy between the heat flux and the electric current within a three-dimensional model it is possible to determine the heat flow in a complete blade, i.e. the full temperature field within the blade and also the local gas side and coolant side heat transfer coefficients. This paper describes the way from temperature measurements at the turbine rotor to the complete temperature field within the rotor blade. Author

N71-17388*# Minnesota Univ., Minneapolis School of Mechanical Aerospace Engineering

FILM COOLING WITH INJECTION THROUGH HOLES

E R G Eckert *In* AGARD High Temp Turbines Jan 1971 19 p refs Sponsored by NASA and the Navy (See N71-17372 07-28)

(NASA-CR-116376) Avail NTIS CSCL 21E

Film cooling with ejection through a row or rows of holes is under consideration for gas turbine blades. Discussed is an analytical approach to the prediction of the effectiveness of this cooling method developed in analogy to a method which proves successful for ejection through a slot and some experimental results which are compared with prediction obtained by this analysis. Author

N71-17389# Centre National de Recherches Metallurgiques, Liege (Belgium)

MEETING REQUIREMENTS FOR HIGH TEMPERATURE GAS TURBINES A CHALLENGE TO METALLURGISTS

D Coutsouradis *In* AGARD High Temp Turbines Jan 1971 17 p refs (See N71-17372 07-28)

Avail NTIS HC $6.00/MF $0.95

Metallurgists involved in the development of materials for high temperature gas turbines are challenged by problems of increasing difficulty leading them to explore continually new areas. Some of the current approaches used for the improvement of cobalt and nickel base alloys are reviewed and illustrated. The scope is not limited to an increase in strength but also to insuring structural stability, hot corrosion resistance, coatability. Processing variables such as hot deformation of normally cast alloys, controlled and directional solidification of conventional or eutectic type alloys, powder metallurgy techniques are evaluated. Author

N71-17390# National Gas Turbine Establishment, Pyestock (England)

FIBRE STRENGTHENED NICKEL-BASE ALLOY

A W H Morris and A Burwood-Smith *In* AGARD High Temp Turbines Jan 1971 15 p refs (See N71-17372 07-28)

Avail NTIS HC $6.00/MF $0.95

The development and application of high temperature composites for gas turbine blading is discussed. Of the currently available reinforcements examined, only tungsten-5% rhenium wire affords acceptable stability in nickel-base alloys and a satisfactory increase in stress-rupture strength, but only by incurring a weight penalty. The maximum volume fraction reinforcement is controlled by composite density and blade geometry; at the low levels imposed the advantage of reinforcement is controlled by composite density and cooled blade. If adopted, fibre reinforcement is likely to be used in solid blades in engine stages where cooling is prohibitive and then only as a selected area reinforcement. Indeed the whole question of application may rest on the thermal fatigue behavior. Laboratory tests on cylindrical specimens indicate very poor thermal fatigue crack resistance. Application of the newer low density single crystal alumina fibre is also discussed. Author

N71-17391# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

THERMO-CHEMICAL PROTECTION OF REFRACTORY SUPERALLOYS FOR AIRCRAFT GAS TURBINES [PROTECTION DES SUPERALLIAGES REFRACTAIRES POUR TURBINES A GAZ AERONAUTIQUES PAR VOIE THERMO-CHIMIQUE]

Philippe Galmiche *In* AGARD High Temp Turbines Jan 1971 12 p refs In FRENCH; ENGLISH summary (See N71-17372 07-28)

Avail NTIS HC $6.00 MF $0.95

A first part of the paper is devoted to a survey of the corrosion problems of refractory materials for gas turbines, as they appear at present in the case of the most advanced superalloys. After recalling briefly the main protection methods of refractory superalloys now in use or under study, the second part of the paper describes the chromaluminization method that has been developed. Author

N71-17392# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Corbeil (France)

MATERIALS DEVELOPMENT FOR HIGH TEMPERATURE TURBINES [EVOLUTION DES MATERIAUX POUR TURBINES A HAUTE TEMPERATURE]

Robert Brunetaud *In* AGARD High Temp Turbines Jan 1971 8 p In FRENCH; ENGLISH summary (See N71-17372 07-28)

Avail NTIS HC $6.00 MF $0.95

Turbine blades and vanes work in complex conditions with creep, thermal fatigue, corrosion, erosion, etc. Base cobalt and base nickel alloys are developed for these turbine parts in new processes (vacuum melting, vacuum precision casting, unidirectional solidification). Spectacular advantages are possible with niobium alloys but the problems of niobium coatings are not resolved. Low cycle fatigue has to be considered more than creep aspects in disk fabrication. New techniques of isothermal forging or the use of wrought sintered products are indicated for the manufacturing of modified alloys from materials used for blades. Author

N71-17393*# Solar, San Diego, Calif

THE COMPOSITION, MICROSTRUCTURE AND PROTECTION AFFORDED BY SEVERAL COMMERCIAL COATINGS ON TWO NICKEL-BASE ALLOYS

A R Stetson and V S Moore *In* AGARD High Temp Turbines Jan 1971 66 p refs (See N71-17372 07-28)

(Contract NAS3-9401)

(NASA-CR-116374) Avail NTIS CSCL 11F

Six commercially available aluminide coatings were evaluated by simulated turbine environmental testing. The environment was the combustion products of JP-5 fuel and air at 0.25 Mach. Coating performance was assessed by weight change and metallographic methods. Electron microprobe X-ray analysis and, to a limited extent, X-ray diffraction were carried out to identify phases and define compositional differences which could be related to performance. Types of aluminide coatings included in this evaluation program

were those containing significant quantities of (1) silicon, (2) chromium applied either before or after the aluminum, and (3) ceramic material. Coatings were also represented that were hyper- and hypo-stoichiometric in the betaNiAl system. In general, the coatings with the greatest initial aluminum reservoir (thickness) provided the greatest protection. Hyper- rather than hypo-stoichiometric coatings appeared to provide longer protection at the maximum test temperature. The substrate also influenced coating performance with the coatings on B1900 showing consistently better performance than coatings on IN-100. Author

N71-17394# von Karman Inst. for Fluid Dynamics, Rhode Saint Genese (Belgium).

APPLICATION OF FILM COOLING TO GAS-TURBINE BLADES

C. Liess and J. Carnel *In* AGARD High Temp. Turbines Jan. 1971 11 p ref. (See N71-17372 07-28)

Avail: NTIS HC $6.00 MF $0.95

The injection of a secondary flow into a high velocity main stream was investigated. The secondary flow was heated and injected by a row of inclined holes into a main flow at ambient temperature. The geometry of the injection holes and the main flow velocity corresponded to conditions encountered on real turbine blades. After a brief review of the application of film cooling to gas turbine blades the results of the measurements are presented. The tests concerned the adiabatic wall effectiveness and the flow field downstream of the injection hole. The test results show that approximate two-dimensional flow conditions can be obtained not far downstream of the holes provided that the spacing to diameter ratio of the holes is small. Author

N71-17395# Arizona State Univ., Tempe.

EVALUATION OF FILM COOLING PERFORMANCE ON GAS TURBINE SURFACES

D. E. Metzger, J. R. Biddle, and J. M. Warren *In* AGARD High Temp. Turbines Jan. 1971 10 p refs (See N71-17372 07-28)

Avail: NTIS HC $6.00/MF $0.95

Film cooling of gas turbine components is often characterized by relatively short cooled lengths and injection geometries which are dictated primarily by fabrication and stress considerations. For many of the resulting configurations, film cooling information based on adiabatic wall temperatures alone is inadequate for design purposes. In addition, the complexity of the film cooling process makes extrapolation of results from one injection configuration to another uncertain. A transient method is described that has been used to rapidly assess the relative performance of various film cooling configurations. Advantages as well as some inherent disadvantages of the method are discussed. The experimental facilities are described and typical results are presented for a variety of flush, angled injection ports. Emphasis is placed on recent results obtained for high injection rates with variable injection angle where the heat transfer is dominated by the film flow and effective heat transfer coefficients are much larger than those associated with the primary flow alone. Author

N71-17396# Rolls-Royce Ltd., Derby (England). Aero Engine Div.

NOZZLE GUIDE VAN COOLING: THE STATE OF THE ART

G. A. Halls *In* AGARD High Temp. Turbines Jan. 1971 19 p ref (See N71-17372 07-28)

Avail: NTIS HC $6.00 MF $0.95

Reviewed is the present state of the art on air cooling of nozzle guide vanes for aircraft gas turbines. It shows how the design of the cooling system and manufacturing techniques have changed over the years to keep pace with increased turbine entry temperatures. The compromise has gradually shifted towards tailoring the design of the vane to operate within the limitations of available materials. Author

N71-17397# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France).

COOLING OF TURBINE DISTRIBUTION BLADES THROUGH IMPACT EFFECT [REFROIDISSEMENT DES AUBES DE DISTRIBUTEUR DE TURBINE PAR EFFET D'IMPACT]

E. Bassinot *In* AGARD High Temp. Turbines Jan. 1971 19 p refs In FRENCH (See N71-17372 07-28)

Avail: NTIS HC $6.00/MF $0.95

One of the improved methods for turbine cooling is the utilization of the impact effect in generating a discharge flow that allows very sensitive temperature corrections. Discussed are experimental studies that use slotted blades surfaces for distributing cooling air through impacting pressure and theoretical calculations of the effects of certain parameters on the impact. The experimental blade consisted of a heat resistant exterior shell and an inner lining that served as distributor of the cooling air and guided it into the convective cooling regions. The functional motor pressure provided the impact effect. It is concluded that this improved impact cooling method is suitable for distributing blades of advanced turbomachinery. Transl. by G.G.

N71-17398# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

COOLING OF TURBINE BLADES BY LIQUID METALS [REFROIDISSEMENT DES AUBES DE TURBINES PAR LES METAUX LIQUIDES]

E. Le Grives and J. Genot *In* AGARD High Temp. Turbines Jan. 1971 20 p refs In FRENCH; ENGLISH summary (See N71-17372 07-28)

Avail: NTIS HC $6.00/MF $0.95

Mass transfer conditions in thermosyphon or evaporative cycles under high centrifugal acceleration are first briefly analyzed. Sodium potassium alloys are shown to be best suited on account of their heat transfer ability with air cooled exchangers at the blade roots. A high rotation speed test set-up on which the heat flux on the blades is comparable to that of a real turbine has been extensively used for an experimental study of these processes. Both cycles lead to a temperature drop as high as 650 C at the blade tips with a mass flow rate of cooling air of 10 g per sec. kW. However, several advantages are shown to be expectable for the evaporative cycle in view of its application to high temperature gas turbine cooling. Author

N71-17399# Army Aviation Materiel Labs., Fort Eustis, Va.

A FLUID-COOLED 2300 F ENTRY TEMPERATURE AXIAL FLOW TURBINE

Edward T. Johnson *In* AGARD High Temp. Turbines Jan. 1971 17 p refs (See N71-17372 07-28)

Avail: NTIS HC $6.00 MF $0.95

A brief description of the overall program for the design and evaluation of a thermosiphon fluid-cooled axial flow turbine is given. The objective of the program was to demonstrate the thermosiphon system's capability to perform (adequately cool) at an inlet gas temperature of 2300 F. Although the original objective cooling at 2300 F (1260 C) was achieved, difficulty was experienced in obtaining the aerodynamic efficiency, proper fabrication of the blades, and a specific horsepower of 213 HP. Wa. Despite the aforementioned problems, this program did prove the capability of the annular combustor, finned nozzle vanes, and fluid-cooled blade cooling system while operating at gas temperatures of 2350 2450 F. Author

N71-17400# Rolls-Royce Ltd., Derby (England). Aero Engine Div.

THERMAL FATIGUE (FILM)

In AGARD High Temp Turbines Jan 1971 9 p (See N71-17372 07-28)
Avail NTIS HC$6.00/MF$0.95

The incidence of thermal fatigue in cooled turbine blades is illustrated. Problems of this nature have recently been encountered and it is demonstrated how a means of overcoming such problems without resorting to expensive and time consuming rig testing can be provided. Author

N71-17401# National Gas Turbine Establishment, Pyestock (England)
SOME MECHANICAL DESIGN PROBLEMS OF TURBINE BLADES AND DISCS
J B Bullard and B B Baxendale *In* AGARD High Temp Turbines Jan 1971 19 p refs (See N71-17372 07-28)
Avail NTIS HC$6.00/MF$0.95

Internally air cooled turbine rotor blades usually have a non-uniform temperature distribution. The non-uniform stress pattern thus created is redistributed by creep occurring at different rates within the blade depending on the local value of stress and temperature. The effect of this process on the blade life is discussed and experiments to check the validity of some of the assumptions are described. The stress patterns in rotating discs are modified when plastic strain occurs dependent on the strain-hardening characteristics of the disc material. This places limitations on the use of conventional material properties as design data. These limitations and the effect of the material stress-strain curve on stress redistribution are discussed. Author

N71-17402# Air Force Systems Command, Wright-Patterson AFB, Ohio
AIR FORCE AERO PROPULSION LAB. AIR-COOLED TURBINE DESIGN CRITERIA
Jack Richens *In* AGARD High Temp Turbines Jan 1971 6 p (See N71-17372 07-28)
Avail NTIS HC$6.00/MF$0.95

A new technology for gas turbine engines is developed and applied in new engines. In order to accomplish this a phased development cycle has been established that permits high levels of risk in the early stages of development reducing to low levels of risk prior to commitment of the substantial resources necessary for development for production. The development cycle with particular attention to the design or selection criteria that have been or are being successfully applied to air-cooled turbines is described. Author

N71-17403# Rensselaer Polytechnic Inst., Troy, N.Y. Mechanics Div.
STRESS ANALYSIS FOR ELEVATED TEMPERATURE LOW-CYCLE FATIGUE WITH HOLD-TIME
Erhard Krempl *In* AGARD High Temp Turbines Jan 1971 17 p refs (See N71-17372 07-28)
Avail NTIS HC$6.00/MF$0.95

The behavior of structural materials under simulated service conditions at elevated temperature is shown to be characterized by strain rate (frequency) sensitivity, creep, relaxation and cyclic hardening or softening. These phenomena and prior deformation history have a considerable effect on the subsequent deformation and fracture behavior. A realistic stress analysis for elevated temperature low-cycle fatigue with hold time has to consider these material properties so that the stresses can be computed throughout the component as a function of time. It is shown that none of the conventionally used descriptions of material behavior (elasticity, plasticity, creep or viscoelasticity) can reproduce all the important observed phenomena. A new approach is proposed which considers time dependent, nonlinear, and history effects. Author

N71-17404# Societe Nationale d'Étude et de Construction de Moteurs d'Aviation, Villaroche (France)
TECHNOLOGICAL ASPECTS OF TURBINE BLADE COOLING BY AIR FILM [LES ASPECTS TECHNOLOGIQUES DU REFROIDISSEMENT DES AUBES DE TURBINE PAR FILM D'AIR]
Jacques M Bertrand *In* AGARD High Temp Turbines Jan 1971 18 p (See N71-17372 07-28)
Avail NTIS HC $6.00/MF $0.95

Technological aspects of placing cooling air emission holes in turbine blade tip portions are considered by evaluating mechanical blade resistance, internal duct organization resulting in an air film, and fabrication methods suitable for multiple cooling. Theoretical and experimental studies of the operational problems connected with the multiple hole cooling method for turbine blades prove the validity of the concept for application in technically advanced turbo machinery. Transl by G G

N71-19177# Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT ON THE AGARD PROPULSION AND ENERGETICS PANEL, 34th MEETING, (8TH COLLOQUIUM) ON REACTIONS BETWEEN GASES AND SOLIDS
S S Penner (California Univ La Jolla) and P G Atkinson Jr (Directorate of Labs, Andrews AFB, Md) Feb 1971 12 p Conf held at Dayton, Ohio, 13-16 Oct 1969
(AGARD-AR-32-71) Avail NTIS

A report of the round table discussion and a critical review of the presentations are given. There was general agreement that the interdisciplinary character of the meeting had led to a fruitful exchange of views by giving new perspectives to the participants on areas of application of their work and on desirable directions for new studies. Author

N71-22599*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
HIGH TEMPERATURE TURBINES
Jack B Esgar and R A Reynolds (Dept of Ind, Trade and Com, Ottawa) Paris AGARD Feb 1971 7 p refs Presented at the 36th Meeting of the Propulsion and Energetics Panel, Florence, 21-25 Sep 1970
(NASA-TM-X-67123, AGARD-AR-29-71) Avail NTIS CSCL 21E

State of the art review of high temperature turbine technology was provided at this conference. The following topics were covered by papers presented: problems involved in cooling small turbines, application of turbine blade cooling to engines, selection of high temperature and cooled turbine materials, heat transfer measurement techniques, and an evaluation of the techniques of film, convection, and transpiration cooling. E M C

N71-26951# Advisory Group for Aerospace Research and Development, Paris (France)
SMALL GAS TURBINES FOR HELICOPTERS AND SURFACE TRANSPORT
May 1971 141 p refs
(AGARD-LS-46-71) Avail NTIS

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6 APPLICATION TO POWER GENERATION A L Jaumotte (Brussels Univ., Belgium) 25 p refs (See N71-26957 15-28)

7 FUTURE DEVELOPMENTS OF SMALL GAS TURBINES J Melchior (Atelier de Construction d'Issy-les-Moulineaux, France) 35 p (See N71-26958 15-28)

N71-26952# Army Materiel Command, Washington D C Ground Mobility Div

MILITARY AND CIVILIAN NEEDS FOR SMALL GAS TURBINES

Donald D. Weidhuner *In* AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 11 p (See N71-26951 15-28)

Avail NTIS

The most important consideration in the selection of a power plant for any application is to maximize return on investment, or to maximize cost effectiveness. it must be indicated that the small gas turbine can yield more return or profit while satisfying operational requirements, than other engines, or its choice cannot be justified The critical requirements of the propulsion systems for helicopters, vehicles, marine craft, electrical power generation, and total energy systems for buildings are discussed, and the engine characteristics necessary for the turbine to be the preferred choice are indicated Installation requirements and ancillary components, exhaust emission levels and certain other technical goals are specified Small gas turbines are arbitrarily considered to be less than 2,000 HP or less than 10 lb/sec airflow Author

N71-26953# United Aircraft of Canada, Longueuil (Quebec)

THE STATE OF THE ART OF SMALL GAS TURBINE ENGINES FOR HELICOPTERS AND SURFACE TRANSPORT

H H Langshur and B J Palfreeman *In* AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 16 p refs (See N71-26951 15-28)

Avail NTIS

The current technical and market status of below 1000 SHP turboshaft engines, as applied to helicopters and surface transport are reviewed Major data are given for the successful engines and comparisons of salient design features are made Engines now in development are discussed On the basis of an industry survey, advances to be expected in a 1980 helicopter engine are described and the expectations are critically reviewed 1980 surface transportation engines are treated similarly, though in less technical detail The main challenges for the engine designer and manufacturers in the surface transport field are brought out Author

N71-26954# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche (France)

CYCLES OF A GAS TURBINE [CYCLES DE TURBINES A GAZ]

P Alesi and R Laurens *In* AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 11 p In FRENCH (See N71-26951 15-28)

Avail NTIS

The power of a gas turbine is defined by the following four parameters air flow, overall pressure ratio, turbine inlet temperature, and components efficiencies The flow depends directly on turbomachine geometry whereas the compression rate is a cyclic variable The temperature in front of the turbine is also a cyclic variable but its value is limited by cooling problems of the turbine materials Compression output and loss are functions of geometry at each cycle stage before flow clearance is minimized through increased compression It is concluded that the power of a gas turbine is primarily determined by its thermodynamic cycle and its geometrical shape Transl by G G

N71-26955# Kloeckner-Humboldt-Deutz A G, Oberursel (West Germany)

ANALYSIS OF SMALL GAS TURBINE ENGINE COMPONENTS

Erwin Schnell *In* AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 23 p refs (See N71-26951 15-28)

Avail NTIS

Aircraft gas turbines are to be developed for lowest weight and smallest volume, therefore they are built without utilization of the exhaust heat but for high pressure ratios For vehicle gas turbines, however, the specific fuel consumption is the determining factor and therefore the heat exchanger is an essential component of the engine For small gas turbine engines cooled turbine blades can only be used to a limited extent In certain cases higher efficiencies can be expected with radial turbines than with axial turbines having unfavorable aspect ratios Two shaft engines (having a free power turbine) compete with single shaft engines, auxiliary attachments (hydraulic torque converter or hydrostatic transmission) render the single shaft engine feasible to be used for traction purposes Author

N71-26956# Rolls-Royce, Ltd, Watford (England) Small Engine Div

INDUSTRIAL AND TECHNOLOGICAL PROBLEMS OF SMALL GAS TURBINES FOR HELICOPTERS AND GROUND TRANSPORT

R M Lucas *In* AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 13 p (See N71-26951 15-28)

Avail NTIS

After considering why a small engine needs to rotate fast, and be made of integral rather than built up parts, some of the consequent vibratory problems are discussed with the conclusion that methods of introducing damping into the system are required Fuel system limitations due to dirt being the same size for big and small engines limit the use of scaled down large engine designs Contamination of compressors by foreign objects is similarly more pronounced A number of workshop problems special to small size are considered and shown to respond to the use of suitable techniques Finally a glance at some of the costs which don't scale indicate proportionately high launching costs Author

N71-26957# Brussels Univ (Belgium)

APPLICATION TO POWER GENERATION

Andre L Jaumotte *In* AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 25 p refs In FRENCH and ENGLISH (See N71-26951 15-28)

Avail NTIS

The applications of gas turbines of low power (below 500 kW) in the fields of aeronautics industry and space are reviewed and the advantages and drawbacks of gas turbines in comparison with Diesel engines are discussed The use of small turbines for the combined production of electric and thermal energy is considered The thermodynamic characteristics of the total energy system are described and a few examples of industrial applications given Possibilities offered by the use of gas turbines in space research especially as regards the production of the energy required on board exploration vehicles are outlined Author

N71-26958# Atelier de Construction d Issy-les-Moulineaux (France)

FUTURE DEVELOPMENTS OF SMALL GAS TURBINES

(DEVELOPPEMENTS FUTURS DES PETITES TURBINES A GAZ)
Jean Melchior *In* AGARD Small Gas Turbines for Helicopters and Surface Transport May 1971 35 p In FRENCH and ENGLISH (See N71-26951 15-28)
Avail NTIS

Light engines with powers ranging between 300 and 1500 hp will be essentially used for the propulsion of ground vehicles that is for industrial applications 1.5 kg of weight per hp should satisfy most users A lower weight will be appreciated, of course but not at any cost Fuel consumption in particular, will remain an important item in the cost of operation Besides, the air intake filtering, sound-proofing and exhaust devices are costly and bulky Since they are proportional to the air flow rate, they will be three times larger for a turbine than for a diesel engine The cost per hp of present diesel engines remains an objective for the gas turbine to reach Now, this cost should still decrease considerably with high super charging simultaneously with the weight per hp which should reach 1 kg/hp in the near future The essential asset of the turbine is its extremely light weight which is however counterbalanced by the heat recovery device Author

N72-16685# Advisory Group for Aerospace Research and Development, Paris (France)
INLETS AND NOZZLES FOR AEROSPACE ENGINES
Dec 1971 503 p refs Partly in ENGLISH and FRENCH Presented at the 38th Meeting of AGARD Propulsion and Energetics Panel Sandefjord, Norway, 13-17 Sep 1971 (AGARD-CP-91-71 UDC 533.697) Avail NTIS HC $6.00 MF $0.95

Conference papers are presented on five topics engine-airplane interference representation in wind tunnel testing, thrust vectoring and control V/STOL inlets and nozzles, supersonic inlets, nozzles, and applications, and subsonic and transonic aeropropulsion For individual titles, see N72-16686 through N72-16718

N72-16686# New York Univ N Y Aerospace Lab
REVIEW OF THE CONCLUSIONS OF THE AGARD AD HOC COMMITTEE ON ENGINE AIRPLANE INTERFERENCE AND WALL CORRECTIONS IN TRANSONIC WIND TUNNEL TESTS
Antonio Ferri *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 10 p (See N72-16685 07-28)
Avail NTIS HC $6.00 MF $0.95

A program for the study of problems of engine-airplane interference is outlined Engine simulators, nozzle design and dynamic characteristics of the inlet are considered K P D

N72-16687# National Aerospace Lab Amsterdam (Netherlands)
INLETS-AIRPLANE TESTING IN TRANSONIC WIND TUNNELS
F Jaarsma *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 15 p refs (See N72-16685 07-28)
Avail NTIS HC $6.00 MF $0.95

The results and recommendations on inlet testing in transonic wind tunnels are discussed in detail Special attention is directed towards mass flow measurements external drag determination, boundary layer representation for diverters and bleeds, and non steady flow phenomena in inlets Author

N72-16688# Naval Postgraduate School Monterey Calif
NOZZLE AND EXHAUST TESTING IN TRANSONIC FLIGHT REGIME
Allen E Fuhs *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 32 p refs (See N72-16685 07-28)
Avail NTIS HC $6.00 MF $0.95

A survey of engine airframe interference is presented In the early stages of development wind tunnel tests of nozzles and exhausts were conducted both alone and in models of the afterbody Thrust measurements were made in test facilities at sea level and various altitudes followed by flight tests Drag of nozzle, boattail, etc) was determined as well as thrust Simulation of exhaust of hot and cold gases, ejectors, and powered simulators is an important facet of testing Nonsteady aerodynamics of internal and external flow and aeroelastic phenomena need to be examined These topics are discussed for both podded and buried engines Major conclusions of the study related to exhausts and nozzles are given Author

N72-16689# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
PROBLEMS OF MEASUREMENT ON MODEL OF THE THRUST OF A SUPERSONIC AIRCRAFT AFTER-BODY STANDARD NOZZLES
Bernard Masure *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 15 p refs In FRENCH, ENGLISH summary (See N72-16685 07-28)
Avail NTIS HC $6.00/MF $0.95

A technique for wind tunnel measurement, through an upstream cylindrical strut, of the thrust of an afterbody is described With this measurement it is possible to correct the global measurements made on complete models with simplified hollow nacelles Precision is checked by various calibrations including tests on a standard convergent divergent nozzle Checking and analyzing of results for complex configurations, including a primary convergent nozzle, are based on knowledge of mass flow rates and thrusts of corresponding sonic nozzles Data concerning such nozzles result from precise tests performed within the atmosphere, without external flow, for a wide variety of shapes The results are presented and compared with theoretical data Author

N72-16690# Centre d'Essais de Propulseurs Saclay (France)
TEST METHODS AND EXAMPLES FROM THE PROPULSION TEST CENTER
Jean Claude Ripoll and Jean Bernard Cocheteux *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 17 p In FRENCH (See N72-16685 07 28)
Avail NTIS HC $6.00 MF $0.95

The Propulsion Test Center is a French government establishment which participates in the development of aeronautical engines using industrial test methods of flight simulation Equipment at the facility includes principally exhaust air and gas treatment apparatus (using either electricity or vapor), a complex network of conduits 8 engine test cells for flight simulation and 7 test jets Measurements are controlled by a central coordinator Among tests made on air inlets and nozzles, tests on the Concorde aircraft are noted, as well as those on noise and thrust Transl by K P D

N72-16691# National Gas Turbine Establishment Farnborough (England)
MEASUREMENT FULL-SCALE OF PROPELLING NOZZLE PERFORMANCE IN AN ATTITUDE TEST FACILITY
J C Ascough *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 12 p ref (See N72-16685 07 28)
Avail NTIS HC $6.00 MF $0.95

Full scale thrust performance tests are described which were made in an altitude test cell on a prototype two stream propelling nozzle fitted to a turbojet engine installed within a simulated aircraft nacelle The ... were made at conditions representing flight at Mach 2 at 20 km altitude Nozzle thrust efficiency obtained from these full scale tests was compared with that from a 1 10 scale model test rig The preliminary analysis gave unexpectedly low full scale efficiencies and, to investigate this, special tests were made with the secondary part of the nozzle removed As a result of the primary nozzle test corrections were made to secondary nozzle test points which yielded satisfactory agreement between full scale and model Author

N72-16692*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio
INLET ENGINE NOZZLE WIND TUNNEL TEST TECHNIQUES

D N Bowditch *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 16 p refs (See N72 16685 07 28)
(NASA-TM-X-67494) Avail NTIS CSCL 20D

Experimental investigations of the inlet, engine, and exhaust nozzle of a supersonic propulsion system are described. Exhaust nozzle results are presented which are compared with wind tunnel and flight results to assess the accuracy of flight measurements. Comparisons are also presented for nozzle performance obtained with a cold jet, a powered turbojet simulator, and a solid jet boundary simulator. The effect of the local boundary layer on nozzle performance is also discussed. The need for good dynamic measurements during inlet-engine testing is illustrated for transients such as inlet unstart and engine stall. The transient nature of inlet distortion and its effect on the engine are presented for two different operating conditions. Author

N72-16693* National Research Council of Canada, Ottawa (Ontario) Div of Mechanical Engineering
WIND TUNNEL TESTING OF V/STOL ENGINE MODELS. SOME OBSERVED FLOW INTERACTION AND TUNNEL EFFECTS
R A Tyler and R G Williamson *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 12 p refs (See N72-16685 07-28)
Avail NTIS HC $6 00/MF $0 95

The interpretation of force measurements on V/STOL related models incorporating inflows and/or outflows is discussed in relation to investigations concerned mainly with the transition performance of lift fan configurations. These utilize balance-mounted, powered models of about 1000 hp in the closed test section of a 10 ft x 20 ft V/STOL propulsion tunnel. With models producing strong downwash, an overriding testing limit arises in closed wind tunnels from the formation of a stable floor vortex system due to the interaction of stagnating model flow with the mainstream. An experimental study of this effect as it relates to downward directed jets is described. Vortex formation limits are correlated in terms of a jet force coefficient for a wide range of jet inclinations to the vertical, and for both single and paired jets. Interference velocity measurements with limited data from the main program and other sources are used to deduce corresponding tunnel flow breakdown limits. These testing limits are shown to be sensitive to model characteristics. Author

N72-16694* LTV Aerospace Corp Dallas Tex
VECTORED THRUST IN AIR COMBAT
C R James *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 8 p ref (See N72 16685 07 28)
Avail NTIS HC $6 00/MF $0 95

Advantages of thrust vectoring in air combat are evaluated using a manned air combat simulator. This simulator consists of two fighter cockpits linked by digital computer driven visual displays which present each pilot with a properly oriented image of the opponent aircraft. Real time digital computation permits each pilot to fly his aircraft anywhere within the performance and strength limits of the airframe as he strives to maneuver into position to fire his weapons. Engagements include three cases (1) a baseline conventional fighter, (2) a vectored thrust version of the baseline, and (3) the vectored thrust configuration with a 1500 pound weight penalty. The conventional fighter is the common opponent for all engagements. Engagements are scored by relative time in advantageous positions and by win/lose/draw results. Advantages of thrust vectoring are quantified and the sensitivity of advantages to weight penalty is determined. The experiments are described, results are summarized and analyses presented based on aircraft performance parameters. Results are also correlated with previous experiments. Author

N72-16695* Motoren Und Turbinen Union Muenchen G m b H (West Germany)
AERODYNAMICS OF THRUST REVERSER DESIGN
W J Lewis (Rolls Royce Ltd Bristol Engl) and H Prechter *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 11 p ref (See N72-16685 07 28)
Avail NTIS HC $6 00/MF $0 95

For a number of applications the clamshell target type thrust reverser is an attractive solution for producing a braking force from a jet engine. This type of reverser consists of a pair of buckets which in the stowed position form part of the aircraft fuselage or engine nacelle and are moved into the jet efflux downstream, from the final nozzle to provide thrust reversal. The important geometric design parameters can be determined from consideration of the flow in the thrust reverser system. Their effect on the aerodynamic performance was established from model tests and is discussed in detail. For the optimization of the operating mechanism in connection with fail-safe requirements, the load on the bucket and its point of application is important and is related to the reverser geometry. The problem of hot gas and debris ingestion into the engine intake is pointed out. Several solutions to overcome this problem are investigated together with the implications they have for performance and design. Author

N72-16696* Societe Nationale d'Etude et de Construction de Moteurs d'Aviation Villaroche (France)
INFLUENCE OF CERTAIN CHARACTERISTIC PARAMETERS ON EJECTOR PERFORMANCE
Jean Marie Hardy *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 12 p refs In FRENCH (See N72 16685 07 28)
Avail NTIS HC $6 00/MF $0 95

The optimization parameters for the adaptation of an afterbody are presented and the principles of the theoretical calculation method for ejector performance are considered. A study of the effects of geometric parameters on internal and external nozzle performance is reviewed based on the results of theoretical and experimental calculations. The internal adaptation of the ejector was investigated as well as the choice of position for secondary ventilation, considering the effect of hot gas. Optimization of global performance by choosing the value and form of the ejector section are also presented. Several theoretical and experimental results are given. Transl by K P D

N72-16697* Royal Aircraft Establishment Bedford (England)
SOME APPLICATIONS OF BOUNDARY LAYER CONTROL BY BLOWING TO AIR INLETS FOR V/STOL AIRCRAFT
I McGregor *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 13 p refs (See N72 16685 07 28)
Avail NTIS HC $6 00/MF $0 95

The use of jet blowing as a means of boundary layer control in intakes appears to have several advantages for V/STOL aircraft. The principles involved are discussed, giving two examples: a two dimensional inlet under static conditions and a ducted lifting fan at low forward speed. Some results of the effects of slot blowing on the behavior of the intakes of a model of a V/STOL strike aircraft at subsonic speeds are presented and compared with those obtained using a naturally aspirated suction bleed. It is concluded that boundary layer control by blowing could lead to a small improvement in net thrust and a significant reduction in flow distortion at entry to the compressor. Sensitivity of intake performance to incidence is also much reduced. Author

N72-16698*# De Havilland Aircraft Co Ltd Downsview (Ontario)
SOME ASPECTS OF PROPULSION FOR THE AUGMENTOR WING CONCEPT
D C Whittley *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 14 p refs Sponsored in part by NASA Defence Res Board of Canada and Canadian Dept of Ind (See N72 16685 07 28)
(NASA-CR-125540) Avail NTIS CSCL 21E

Many modern concepts for STOL and V/STOL aircraft rely on integration of the propulsion system with the wing to create favorable lift interactions, and are known as powered lift concepts. A study of powered lift, concerning management and control of the various propulsive streams or jets, is presented, each concept having its own particular objectives and requirements. Some specific objectives of this kind are described which relate to the augmentor wing. Consideration is given to three aspects of the subject, namely the augmentor flap itself, the wind ducting and augmentor primary nozzle and the choice of powerplant or engine cycle. More generally, comments are made regarding noise attenuation and the prospect for achieving a low overall noise level for jet STOL aircraft of the future.
Author

N72-16699# Rolls Royce Ltd., Derby (England). Engine Div.
RAPID MIXING NOZZLES FOR V/STOL APPLICATIONS
C. M. Chesters *In* AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971 11 p refs (See N72-16685 07-28)
Avail: NTIS HC $6.00/MF $0.95

If the maximum potential of a V/STOL aircraft is to be achieved, it must be capable of operating from a variety of both prepared and unprepared sites. The use of high thrust to weight ratio jet lift engines with convergent or annular nozzles restricts this capability due to ground erosion, debris and hot gas recirculation and noise. Model and full scale tests demonstrated the benefits to be obtained from the use of rapid mixing nozzles with acceptable thrust lost and engine length penalties. The scope of the investigation extended to an examination of the possibilities of thrust vectoring and of the performance of thrust augmentors using rapid mixing nozzles.
Author

N72-16700# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Luftsaugende Antriebe Eng. Dec. 1971 10 p
THE PROPULSION JET OF A VTOL AIRCRAFT
E. Schwantes *In* AGARD Inlets and Nozzles for Aerospace refs (See N72-16685 07-28)
Avail: NTIS HC $6.00/MF $0.95

The three regions of a vertical takeoff propulsion jet (the free jet, the wall jet and the zone of separation of the wall jet from the ground due to wind effects and buoyancy forces) were investigated with a three dimensional model jet. Behind the convergent nozzle the jet accelerates up to supersonic velocity maintaining the core nearly five nozzle diameters. Because of the lower turbulence of the jet with high speed jet decay and the three dimensional spread are lower than those of the jet with small nozzle velocity. At the hot wall jet there is a strong influence of nozzle distance from the ground or velocity profile. The decisive parameter characterizing the recirculation flow is the radius of separation of the wall jet from the ground. The behavior of the radius of separation for different jet parameters and several wind velocities is presented.
Author

N72-16701# Von Karman Inst. for Fluid Dynamics, Rhode-Saint Genese (Belgium).
FLOW ANALYSIS IN AXISYMMETRIC SUBSONIC INLETS OF SMALL GAS TURBINES
P. M. Gallet *In* AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971 15 p refs Prepared in cooperation with Ecole Royale Militaire (See N72-16685 07-28)
Avail: NTIS HC $6.00/MF $0.95

Complicated axisymmetric air inlets are used in small gas turbines, thus disturbing the flow at the compressor entrance. A streamline curvature method to calculate the flow in the passage and at the compressor eye is presented. A universal theory of the discontinuities of curvature was applied. Additional annulus boundary layer calculations may help in the analysis of a channel. Some experimental and theoretical results are shown which tend to confirm the validity of the theory.
Author

N72-16702# National Research Council of Canada, Ottawa (Ontario). Div. of Mechanical Engineering.
FLOW DISTORTION AND PERFORMANCE MEASUREMENTS ON A 12 INCH FAN-IN-WING MODEL FOR A RANGE OF FORWARD SPEEDS AND ANGLE OF ATTACK SETTINGS
Uwe W. Schaub and Robert W. Bassett *In* AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971 13 p refs (See N72-16685 07-28)
Avail: NTIS HC $6.00/MF $0.95

The model comprising a 12-in. diameter fan buried in a NACA 0015 section wing with a constant chord of 40 in., was tested at various angles of attack and air speeds in the 10x20 ft closed propulsion wind tunnel. Tunnel interference corrections were estimated. Typical corrections were indicated for the whole testing range which became limited at very low crossflow ratios as a result of uncertainty in the correction in angle of attack. Flow distortion due to crossflow occurred in both the inlet and exit planes. In the crossflow ratio range zero to 0.27 inflow distortion was observed to be velocity distortion at essentially constant total pressure, whereas outflow distortion appeared to be a distortion of the exit plane static pressure field.
Author

N72-16703# Boeing Co., Seattle, Wash.
THE DESIGN, DEVELOPMENT, AND TESTING OF A SUPERSONIC TRANSPORT INTAKE SYSTEM
E. Tjonneland *In* AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971 17 p refs (See N72-16685 07-28)
Avail: NTIS HC $6.00/MF $0.95

The performance criteria, including engine airflow matching requirements, of an axisymmetric mixed-compression intake for a supersonic transport application are described and related to the selection of the design features of the intake variable-geometry components. Viscous technology is applied to the design and development of the boundary layer control system to account for intake viscous interactions and to scale model results to full-scale designs. Small, low angle bleed holes 20 deg to the surface yield high flow coefficients. Hole diameters of approximately half the height of the boundary layer displacement thickness are used to improve the cleanliness of the supersonic diffuser flow and to maximize pressure recovery of the bleed air. Vortex valves are incorporated in a fluidic normal shock stability system to allow operation at peak intake recovery and remain started during atmospheric or engine transients.
Author

N72-16704# National Gas Turbine Establishment, Pyestock (England). Engine Test Dept.
FREE-JET TESTS OF A FULL SCALE SUPERSONIC INTAKE ENGINE COMBINATION
P. F. Ashwood *In* AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971 19 p refs (See N72-16685 07-28)
Avail: NTIS HC $6.00/MF $0.95

Results are presented from an experimental investigation on a full scale Concorde power plant in 5 ft x 5 ft free jet test facility to investigate intake engine compatibility at supersonic speeds under both steady state and transient conditions. The main aim of the test program was to study the behavior of the power plant when running under the control of its flight systems, in particular during the transients that result from the sudden application of side slip or from rapid engine power changes. Initial tests with the intake alone enabled surveys to be made of the engine face pressure distribution and fluctuation over a wide range of test conditions. The major part of the program was undertaken with an Olympus 593 two spool turbojet engine coupled to the intake in a test configuration which reproduced the precise geometry of the port outer power plant of the prototype Concorde aircraft.
Author

N72-16705# British Aircraft Corp., Filton (England). Commercial Aircraft Div.
CONCORDE POWERPLANT DEVELOPMENT
C. S. Leyman and D. P. Morriss *In* AGARD Inlets and Nozzles for Aerospace Eng. Dec. 1971 32 p refs (See N72-16685 07-28)
Avail: NTIS HC $6.00/MF $0.95

The development of the Concorde power unit is described with particular reference to the problems encountered during flight testing. The extent to which these problems were predicted by altitude test cell experience and the use of such facilities in the development of the design are also discussed. Author

N72 16706# Boeing Co Seattle Wash
CONTROL CONCEPT AND WIND TUNNEL TESTING OF A SUPERSONIC INTAKE CONTROL SYSTEM
H N Larsen and R G Schweikhardt *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 23 p refs (See N72 16685 07 28)
Avail NTIS HC $6.00 MF $0.95

The controller is independent of other intake controllers and of airplane data systems. During started intake operation throat Mach number is controlled with a translating centerbody and variable position cowl throat doors; normal shock position is controlled with secondary air valves and overboard bypass doors. These two control loops use intake duct pressure ratio signals for feedback. The desired pressure ratio reference value is scheduled with centerbody position and biased with intake controller error signals to provide for varying intake Mach number and angle of sideslip. Using vortex valves as an auxiliary normal shock stability system, model tests showed that the controller can maintain peak intake recovery while accommodating the required disturbances. Hot and cold day engine intake air flow matching is automatically controlled with increased secondary valve air flow or an intake activated engine rpm trim control. An external compression mode which maintains stable intake air flow with low compressor face distortion provides for unstarted supersonic intake operation. Author

N72 16707# General Dynamics Fort Worth Tex Convair Aerospace Div
AN AERODYNAMIC DRAG STUDY OF JET ENGINE NOZZLES
Dave Bergman *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 12 p refs (See N72 16685 07 28)
Avail NTIS HC $6.00 MF $0.95

To aid nozzle analysis in areas where analytical methods are lacking, a wind tunnel program was conducted to investigate and measure the external drag characteristics of several nozzles at both on- and off-design exhaust conditions. This study involves nozzles of the centerbody plug, the convergent, and the convergent-divergent types. Flow through nacelle nozzles and solid wall jet plume simulators, each used frequently in airplane model tests, were included in the program. Results show large changes in external drag with variations in exhaust flow and describe the behavior of jet plume shape and entrainment effects. The results also provide insight into methods for simulating exhaust flow effects on airplane models which do not incorporate high pressure exhaust flow. Author

N72 16708# British Aircraft Corp Preston (England)
JET EFFECTS ON BOATTAIL PRESSURE DRAG AT SUPERSONIC SPEEDS
J A P Stoddart *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 11 p refs (See N72 16685 07 28)
Avail NTIS HC $6.00 MF $0.95

An analysis is presented of supersonic boattail pressure drag measurements in the presence of single or twin propulsive jets. Using theoretical inviscid pressure distributions as a datum, the decrease in boattail pressure drag coefficient with increasing nozzle pressure ratio is shown to be a function of the difference between the measured base pressure coefficient and a reference base pressure coefficient. The boattail shapes are shown to fall into two groups, one of which experiences a much stronger influence of the propulsive jet than does the other. Correlations of measured base pressure coefficient in the presence of a propulsive jet are also presented for convergent and con-di nozzles. Author

N72 16709*# National Aeronautics and Space Administration Flight Research Center Edwards Calif
A FLIGHT INVESTIGATION OF STEADY STATE AND DYNAMIC PRESSURE PHENOMENA IN THE AIR INLETS OF SUPERSONIC AIRCRAFT
Frank W Burcham Jr and Donald R Bellman *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 12 p refs (See N72 16685 07 28)
(NASA TM X 67495) Avail NTIS CSCL 20D

The difficulty of achieving adequate inlet performance and stability and avoiding engine compressor stalls at supersonic speeds has led to the investigation of pressure phenomena in the inlets of several supersonic aircraft. Results of tests with the F 111A airplane are presented showing the inlet steady state and dynamic performance. The inlet total pressure distortion that causes compressor stall is discussed and the requirement for high response instrumentation is demonstrated. A duct resonance encountered at Mach numbers near 2.0 is analyzed and shown to be due to a normal shock oscillation at the duct fundamental frequency. Another type of resonance in the engine fan duct is shown to be a possible cause of reduced engine stall margin in afterburning operation. Plans for a comprehensive inlet study of the YF 12 airplane are discussed including flight tests and full scale, 1/3 scale, and 1/12 scale wind tunnel tests. Author

N72 16710# Air Force Flight Dynamics Lab Wright Patterson AFB Ohio
SUPERSONIC INLET PERFORMANCE AND DISTORTION DURING MANEUVERING FLIGHT
L E Surber and D J Stava *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 18 p ref (See N72 16685 07 28)
Avail NTIS HC $6.00 MF $0.95

Several possible vehicle configurations are presented and discussed to point out inherent advantages and disadvantages in terms of airframe inlet integration and mission accomplishment. Features of the forebody and forebody wing configurations are presented together with wind tunnel test data comparing the inlet flow fields of these models. Techniques are described for design air inlets for the airframe flow fields. It also describes the instrumentation employed to document inlet performance. Air inlet performance and duct flow distortion from wind tunnel tests of different model designs are compared to show the effects of aircraft geometry, air inlet design, and maneuver condition over the 0.6 to 2.5 Mach number range. Author

N72 16711# Pratt and Whitney Aircraft West Palm Beach Fla
INLET ENGINE COMPATIBILITY ANALYSIS
S H Ellis *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 10 p refs (See N72 16685 07 28)
Avail NTIS HC $6.00 MF $0.95

The destabilizing factors considered in compatibility analysis are reviewed, instrumentation and test techniques are discussed, and examples of compatibility data are given for a propulsion system consisting of a supersonic inlet and a turbofan engine. The primary destabilizing factor, inlet distortion, is measured with high response instrumentation capable of describing complex time variant distortion patterns. The maximum time variant distortions determined from model inlet tests are simulated during component and engine testing to define both loss in stall margin with distortion and the attenuation of distortion as it passes through the engine. The losses in stall margin due to engine causes such as throttle transients, control tolerances and component interactions are analyzed by dynamic simulation to identify potential system problems prior to system testing. Attention is focused on potential problems by compatibility audits that show the allocation of stall margin between destabilizing influences and identify areas where component improvement is needed. Author

N72 16712# Politecnico di Milano (Italy) Ist di Macchine
ON THE APPLICATION OF A TIME DEPENDENT TECHNIQUE IN TRANSONIC DOUBLE FLOW NOZZLE SOLUTIONS

Carlo Osnaghi and Ennio Macchi *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 15 p refs (See N72 16685 07 28)
Avail NTIS HC $6 00 MF $0 95

A computer program was written which was able to solve axisymmetric inviscid flows contemporarily irrespective of their subsonic transonic or supersonic nature Some results relating to a transonic nozzle and a subsonic double flow nozzle are presented and compared with experimental data Author

N72-16713# Office National d'Etudes et de Recherches Aerospatiales Paris (France)
VELOCITY DISTRIBUTION AT A SUPERSONIC COMPRESSOR INLET
Bernard Ledoux and Roger Bagot *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 10 p In FRENCH, ENGLISH summary (See N72 16685 07 28)
Avail NTIS HC $6 00 MF $0 95

A direct method is derived in which the ideal compressible flow in the duct is established from the duct and the cowl shapes The computed pressure distributions are compared with those on the external shroud and cowl during wind tunnel tests The velocity distribution in the duct is deducted An indirect method is also presented starting from the pressure distribution on the external wall and leading to the flow field The calculation is checked by comparing the streamline corresponding to the set up inlet with the front cowl meridian shape Author

N72 16714# A S Kongsberg Vapenfabrikk (Norway) Gas Turbine Div
THE ANALYSIS OF A SUBSONIC AXISYMMETRIC INLET FOR COMPRESSOR MATCHING
R E Stanley *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 13 p ref (See N72 16685 07 28)
Avail NTIS HC $6 00 MF $0 95

The measured velocity distribution for the original inlet is compared to the distribution obtained by a method of numerical analysis It is shown that the favorable results of this comparison led to the development of the inlet by a method of numerical analysis in preference to a model testing technique The recommendations are presented together with the results of an experimental analysis of the redesigned inlet configuration The method of compressor matching is touched upon Author

N72-16715# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
STARTING CONDITIONS OF A MIXED COMPRESSION AXISYMMETRIC HYPERSONIC INLET
G Laruelle and J Leynaert *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 9 p refs In FRENCH, ENGLISH summary (See N72 16685 07 28)
Avail NTIS HC $6 00/MF $0 95

An improved diagram including an elementary representation of the interaction phenomenon is used By means of this diagram, test data on axisymmetrical inlets at high supersonic speeds are discussed, and the influences of some parameters are calculated Author

N72-16716# Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
THEORETICAL AND EXPERIMENTAL STUDY OF THE COEXISTENCE OF TWO TYPES OF FLOW IN A CHANNEL WITH CONSTANT CROSS SECTION
Jacques Paulon *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 12 p refs In FRENCH, ENGLISH summary (See N72-16685 07 28)
Avail NTIS HC $6 00/MF $0 95

A two-dimensional and an asymmetrical set-up of very similar characteristics, were built to study the coexistence, in a constant section duct, of a supersonic jet inside a subsonic jet The experimental analysis of the flow, made from pressure readings on the walls and inside the fluid, led to characterizing the actual limits of the two flows, and also the transition domain between them In the two-dimensional case, the schlieren visualization of the flow confirms the measurements The theoretical analysis, based on the method of characteristics, confirms the parietal readings The maximum flaring section differs from the sonic section of the external flow, which may lead to faulty predictions in the case of a contoured ejector Author

N72-16717# Technische Hochschule Aachen (West Germany) Inst fuer Strahlantriebe und Turboarbeitsmaschinen
A NEW CONCEPT OF THE INLET DESIG AND OF THE THERMODYNAMIC CYCLE OF THE TURBOJET ENGINE AT HIGH FLIGHT MACH NUMBERS
W Dettmering and B Becker *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 10 p refs (See N72-16685 07-28)
Avail NTIS HC $6 00/MF $0 95

At high supersonic speeds the efficiency of the inlet strongly depends on the diminution of the Mach number before the normal shock Theoretical investigations show that this deceleration can be increased by replacing the internal compression in the bladeless channel by a supersonic rotor Due to the deceleration of the relative flow and the increase of the circumferential velocity from rotor inlet to outlet, a significant augmentation of the static pressure ratio is achieved Moreover, the Mach number can be decreased by the transfer of mechanical energy to the rotor After the transition to subsonic velocities in the stator, the energy was returned to the flow either by a conventional compressor, or by a second supersonic rotor accelerating the flow between the combustion chamber and the nozzle Static pressures and temperatures in this turbojet engine, which operates with subsonic combustion, are comparable to those of the supersonic combustion ramjet Author

N72-16718# Messerschmitt Boelkow-Blohm G m b H , Munich (West Germany)
WIND TUNNEL INVESTIGATIONS OF A SUPERSONIC AIR INTAKE WITH VARIOUS AUXILIARY INTAKES AT LOW SPEEDS
Herbert Eibl and Reinhard Friedrichs (DFVLR, Brunswick) *In* AGARD Inlets and Nozzles for Aerospace Eng Dec 1971 12 p (See N72 16685 07 28)
Avail NTIS HC $6 00/MF $0 95

In the low speed tunnel, model tests were carried out on a twin-engine aircraft configuration with air intakes located on the upper side of the fuselage next to the trailing edge of the wing The measurements refer to the flow field in the compressor inlet area of a supersonic intake at which the influence of auxiliary intakes of different shapes were investigated The results are presented as isobars of the total pressure distribution in the compressor inlet area The pressure loss and distortion parameters are discussed, strongly dependent on the inflow incidence and on the intake flow mainstream ratio Author

N72-21819*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
TECHNICAL EVALUATION REPORT ON PROPULSION AND ENERGETICS PANEL 38TH MEETING ON INLETS AND NOZZLES FOR AEROSPACE ENGINES
David N Bowditch and Rodolfo Monti (Naples Univ) Paris AGARD Feb 1972 6 p refs
(NASA TM-X-67741, AGARD AR-41) Avail NTIS CSCL 21A

The application and use of inlets and nozzles in aerospace, V/STOL, and hypersonic propulsion systems are discussed Data cover test techniques and facilities, experimental results from small rig tests to flight tests and theoretical analysis of propulsion system flows The problems associated with such a system are also discussed E H W

N73-19794# Advisory Group for Aerospace Research and Development, Paris (France)

BOUNDARY LAYER EFFECTS IN TURBOMACHINES

J. Surugue, ed (ONERA, Chatillon-sous-Bagneux, France) Dec 1972 473 p refs In ENGLISH, partly in FRENCH (AGARD-AG-164, AGARDograph-164) Avail NTIS HC $25.75

Studies dealing with the role of boundary layers in turbomachine design and operation are reported The areas of investigation include subsonic, supersonic, and transonic flow machines For individual titles, see N73-19795 through N73-19815

N73-19795 Von Karman Inst for Fluid Dynamics, Rhode-Saint-Genese (Belgium)

ON THE TWO DIMENSIONAL BOUNDARY LAYERS AS THEY APPEAR ON TURBOMACHINE BLADES

K D Papailiou, A Satta (Cagliari Univ), and F Nurzia (Genova Univ) *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 1-27 refs (For availability see N73-19794 10-28)

Universal curves were developed which relate general properties of optimized boundary layers suitable for the critical side of a blade, to overall design variables The problem of maximum deceleration was considered and universal curves were developed which establish the deceleration which can be realized giving a length and the initial conditions for the boundary layer These universal curves were established for incompressible flow Using Le Foll's method with the introduction of a typical Mach number as an additional parameter, it should be possible to extend the universal design curves to compressible flow The effects of curvature on turbulence are discussed and it is shown that Bradshaw's model could be used not only for differential but also for integral methods Author

N73-19796 United Aircraft Corp, East Hartford, Conn Research Labs

PRACTICAL CALCULATIONS OF TRANSITIONAL BOUNDARY LAYERS

H McDonald and R W Fish *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 29-53 refs (For availability see N73-19794 10-28)

A general finite-difference procedure for computing the behavior of compressible two-dimensional boundary layers is presented together with a turbulence model which allows quantitative predictions of the location and extent of the transition region between laminar and turbulent flow as it is influenced by such disturbances as surface roughness and free-stream turbulence Reverse transition, i e, relaminarization, caused by large favorable streamwise accelerations, is also quantitatively predicted by this procedure The solution procedure depends upon the calculation of the streamwise development of a turbulent mixing length whose magnitude is governed by the turbulence kinetic energy equation A large number of comparisons between predictions and measurements were made and in general very good agreement was obtained Author

N73-19797 National Gas Turbine Establishment, Pyestock (England)

PREDICTIONS OF BOUNDARY LAYER TRANSITION ON TURBOMACHINERY BLADES

J Dunham *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 55-71 refs (For availability see N73-19794 10-28)

Transition may occur either in the form of natural transition or as a laminar separation bubble ending in reattachment as a turbulent boundary layer Existing theories of both types are applied to predicting the available transition observations on turbomachinery blading Owing to the high free stream turbulence level in a turbomachine, many blades must exhibit natural transition, but too few experimental measurements are available to test the predictions adequately More experiments were conducted involving bubble transition and after modifying the theory to allow for free stream turbulence predictions agree fairly well with measurements of the position and length of transition bubbles Author

N73-19798 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany) Inst fuer Aerodynamik

INFLUENCE OF THE DEGREE OF TURBULENCE ON THE AERODYNAMIC COEFFICIENTS OF CASCADES

R Kiock *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 73-88 refs (For availability see N73-19794 10-28)

An inviscid degree of turbulence is calculated from the circumferential distribution of the potential flow velocity behind a rotating cascade This is compared with measurements of the degree of turbulence at a stator inlet of a multi-stage axial compressor Extensive measurements on the influence of the turbulence level on the aerodynamic coefficients of several two-dimensional compressor cascades were carried out These contained wake traverses, boundary layer measurements and pressure distribution on the profiles These investigations were carried out in incompressible flow in the range of Reynolds numbers between 90,000 and 270,000 both in a low speed and a high speed cascade wind tunnel Author

N73-19799 Detroit Diesel Allison, Indianapolis, Ind

THE EFFECT OF FREE STREAM TURBULENCE LEVEL ON TURBULENT BOUNDARY LAYER BEHAVIOUR

G David Huffman, D R Zimmerman, and W A Bennett *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 89-115 refs (For availability see N73-19794 10-28)

The results of an experiment to determine the effect of free-stream turbulence level on the classic boundary layer properties indicate the following (1) The boundary layer thickness increases with increasing turbulence level This was considered as being due to the increased entrainment brought about by the highly excited state of the boundary between the shear layer and the free-stream (2) The mean velocity remains largely unchanged in the inner region, however, there is a marked reduction in the wake component as the free-stream turbulence level increases (3) The skin friction increases with increases in the turbulence level (4) The shape factor decreases slightly with increased turbulence level due to the reduced wake component D L G

N73-19800 Motoren- und Turbinen-Union Muenchen G m b H (West Germany)

ANALYTICAL APPROACH FOR THE LOSS AND DEFLECTION BEHAVIOUR OF CASCADES IN TRANSONIC FLOW INCLUDING AXIAL MASS FLOW VARIATION

Leonhard Fottner *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 119-139 refs (For availability see N73-19794 10-28)

The method described contains a calculation of the viscous transonic flow past cascades of slender, slightly cambered profiles, and includes the local supersonic field, the terminal compression shock and a variation of the axial mass flow density across the cascade The influence of a change in axial velocity across the cascade is considered by introducing additional strips of sources and sinks into the singularity method Thus, there are induced velocities on the profile surface which have to be added to the surface velocities of the plane case The local supersonic field which builds up downstream of the sonic point is treated by an empirically corrected supersonic expansion The location strength of the compression shock terminating the supersonic field downstream is obtained by an empirically corrected normal shock relation The viscous effect is determined by means of a boundary layer calculation along the profile contour The problem of interaction between the boundary layer and the normal shock, which is particularly important in the consideration of viscous effects, is closely investigated with the aid of the available test data The entire flow loss is determined from the shock losses and the profile losses The latter are obtained from the boundary layer values at the trailing edge with consideration of possible small separation areas and the mixing losses produced in the wake Author

N73-19801 Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium)
BLADE OPTIMIZATION BASED ON BOUNDARY LAYER CONCEPTS
Shuang Huo *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 141-170 refs (For availability see N73-19794 10-28)

An optimization method based on Le Foll's theory is described. This is an inverse problem where one specifies the optimum boundary layer and obtains the velocity distribution. By using potential methods the corresponding profile or channel shape may be obtained. The calibration procedures for the incompressible and compressible boundary layers are shown. Some examples of the application of the method are given and the work still to be done in the compressible case is discussed. Author

N73-19802 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Porz (West Germany). Inst. fuer Luftstrahlantriebe
INCOMPRESSIBLE FLOW THROUGH CASCADES WITH SEPARATION
W Geller *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 171-186 refs (For availability see N73-19794 10-28)

A singularity method is given for calculating the flow in a cascade with constant blade-surface pressure distribution in the complete region between separation points on the upper and lower surfaces. The contours of blades are replaced by vortex sheets. Source distributions on the contours in the region of separation are used for simulating displacement effects of the separated wake. The position of separation points must be estimated before starting the calculation. Their actual position is found by boundary-layer computation. As shown by comparison of theoretical and experimental results, calculated pressure distributions and flow deflection angles generally agree well with measured data, while the corresponding drag coefficients agree satisfactorily. Author

N73-19803 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
INFLUENCE OF ANGLE OF ATTACK AND DEFLECTION ON BOUNDARY LAYER FLOW IN UPRIGHT CASCADE BLADES [INFLUENCE DE L'ANGLE D'ATTAQUE ET DE LA DEFLEXION SUR LE DECOLLEMENT DE LA COUCHE LIMITE DANS UNE GRILLE D'AUBES DE REDRESSEUR]

Jacques Paulon *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 187-201 refs In FRENCH (For availability see N73-19794 10-28)

Cascade blade performance, as affected by boundary layer flow incidence and strong deflection, is examined. Trailing edge flow, backflow and static pressure degradation are analyzed in detail. Transl. by E.H.W.

N73-19804 Technische Universitaet, Brunswick (West Germany). Inst. fuer Stroemungsmechanik
THE EFFECT OF AXIAL VELOCITY RATIO ON THE AERODYNAMIC COEFFICIENTS OF A COMPRESSOR CASCADE IN VISCOUS FLOW
U Stark *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 205-220 refs (For availability see N73-19794 10-28)

Both theoretical and experimental investigations of the effect of axial velocity ratio on the aerodynamic coefficients of two compressor cascades with NACA 65-(10)06 profiles are described. For the potential flow calculations the Pollard-Horlock method was selected. Boundary-layer calculations were performed based on the potential flow velocity distributions. The aerodynamic coefficients were calculated from the boundary-layer parameters at the blade trailing edge. The experimental investigations were carried out in a low-speed cascade tunnel. Both the theoretical and experimental results show a considerable effect of the axial velocity ratio on the aerodynamic performance of compressor cascades. The agreement between theory and experiment is quite satisfactory in as far as no severe flow separation occurs. Author

N73-19805 Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany)
THE INFLUENCE OF AXIAL VELOCITY DENSITY RATIO ON COMPRESSOR CASCADE PERFORMANCE IN COMPRESSIBLE FLOW
W Heilmann *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 221-240 refs (For availability see N73-19794 10-28)

Results of theoretical and experimental investigations on the influence of the ratio between the axial velocity density upstream and that downstream on the performance of plane compressor cascades in compressible flow are presented. Tests were performed in a 7-inch transonic wind tunnel where upstream turbulence levels were varied. It could be demonstrated that the change in cascade performance with the axial velocity density ratio substantially depends upon the blade boundary layer behaviour. At fully turbulent boundary layers the axial velocity density ratio influences only the separation point positions. At laminar-turbulent boundary layers in addition the transition point position from which the separation point positions depend will be influenced. Boundary layer calculations conducted in the theoretical part of the investigation have qualitatively confirmed the experimentally achieved results as far as the influence of the axial velocity density ratio on the transition and separation point position is concerned. Total pressure loss at various axial velocity density ratios was calculated by applying an approximative method of determining the characteristic boundary layer values in separated flow and then comparing with the test results. Author

N73-19806 Rolls-Royce, Ltd., Bristol (England)
THE ROLE OF BOUNDARY LAYERS IN AXIAL FLOW TURBOMACHINES AND THE PREDICTION OF THEIR EFFECTS
N J Seyb *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 241-259 refs (For availability see N73-19794 10-28)

The prediction of boundary layer conditions within a turbomachine is reviewed from the engine designer's viewpoint. A brief outline of the problems and compromises forced on the aerodynamicist is given followed by a discussion of the boundary layer prediction methods currently in use. Because of the extremely complicated flow patterns present in a turbomachine only the simplest cases (i.e. flow in two-dimensional cascades) have responded adequately to theoretical treatment. Simple and practical methods are described for the prediction of the boundary layer parameters, tran[illegible]d laminar separation points, bubble sizes and heat transfe[illegible]ents, etc. for any cascade, incidence, Reynolds number, turbulence level, etc. Comparisons between experiment and prediction are given and it is shown that there is good agreement. Author

N73-19807 Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany)
A CALCULATION METHOD FOR THE EXTERNAL HEAT TRANSFER TO TURBINE BLADES
D K Hennecke *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 261-273 refs (For availability see N73-19794 10-28)

A complex calculation method was devised to predict the local temperature distribution in a cooled turbine blade. The report is devoted exclusively to one of the key elements of the procedure which is an integral type boundary layer analysis to predict the distribution of the external heat transfer coefficient. The analysis has been adapted to the special requirements of turbine blade cooling research. Thus, it accounts for the combined effects of compressibility, laminar as well as turbulent flow regions, favorable and adverse pressure gradients, smooth and or rough blade surfaces, lateral convergence or divergence and temperature dependent fluid properties. Furthermore, in the evaluation of the heat transfer coefficient, a pressure gradient in flow direction and a longitudinal temperature gradient within the wall are considered. The method also allows injection into the boundary layer, either local (film cooling) or continuous (effusion cooling). Results are presented graphically for a cooled turbine blade with

a certain profile and specified flow conditions For this example, the various features, listed above, were studied individually and the magnitude of their effects on the heat transfer coefficient is demonstrated. Author

N73-19808 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)
METHOD OF CALCULATING THREE DIMENSIONAL TURBULENT BOUNDARY LAYER SEPARATION WITH APPLICATION TO A SIMPLE TURBOMACHINE CASE [METHODE DE CALCUL DE LA COUCHE LIMITE TURBOULENTE TRIDIMENSIONNELLE JUSQU'A LA SEPARATION APPLICATION A UN CAS SIMPLE DE TURBOMACHINE]
R. Michel *In* AGARD Boundary Layer Effects in Turbomachines Dec. 1972 p 277-292 refs In FRENCH; ENGLISH summary (For availability see N73-19794 10 28)

The proposed method is based on the determination of similarity solutions for three-dimensional turbulent boundary layers; solutions established from an improved mixing length model The characteristics of the families of streamwise and crosswise velocity profiles obtained in this way are then used in a method for solving boundary layer global equations Applied and tested previously for aeronautics problems, the technique is extended to treat turbomachinery problems, taking into account, among other things, the effects of rotation walls The case of the swirling flow in the diffuser of a centrifuge compressor is examined, and the position of separation, i.e the circle on which the wall streamlines accumulate, is determined as a function of the inlet angle. It is also found that a rotation at the diffuser walls entails a much slower thickening of the boundary layers, and a noticeable recession of separation. Author

N73-19809 Institute TNO for Mechanical Constructions, Delft (Netherlands).
MEASURED AND CALCULATED TURBULENT BOUNDARY LAYER FLOW IN A VANELESS RADIAL DIFFUSER
C. B. V. D Voorde and J Bos *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 293-310 refs (For availability see N73-19794 10-28)

A method is presented for predicting two-dimensional flow through a radial diffuser with flat parallel walls The method is based on the integral entrainment method and is valid until the flow is fully developed Equations are given for prediction of the velocity distribution across the diffuser width at any arbitrary station, prediction of the radial distribution of the static pressure recovery, and calculation of the diffuser efficiency from the predicted and measured flow An experiment conducted for validation of the prediction method is described During the experiment very accurate measurements were made of the velocity distribution across the constant diffuser width at various stations along a diffuser radius The experimental values concurred well with predicted values D G

N73-19810 Technische Hochschule, Aachen (West Germany) Inst. fuer Strahlantriebe und Turboarbeitsmaschinen
APPLICATION OF BOUNDARY LAYER FENCES IN TURBOMACHINERY
H Pruemper *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 311-331 (For availability see N73-19794 10-28)

The major secondary flows occurring in turbine stages are presented and their causes and their effect on the total flow are discussed Through visualization of the flow lines near the wall and accurate measurement of the three-dimensional loss distribution of cascades with short and longer blades detailed information may be obtained on the mechanism of the secondary flows and the secondary losses thereby produced In the course of experimental tests aimed at possibilities of suppressing secondary flows and secondary losses incidental thereto the method of using boundary layer fences on the profile suction sides of the blades proved to be particularly effective and economical Finally, the experimental results obtained from the application of this method in a turbine stage are presented Author

N73-19811 Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium)
SECONDARY FLOW RESEARCH AT THE VON KARMAN INSTITUTE
J. W. Salvage *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 333-361 refs (For availability see N73-19794 10-28)

Experimental work in cascade secondary flows accomplished in the past ten years is reviewed with the objective of pointing out difficulties common to the field Investigations included tip clearance effects, low aspect ratio effects, and the beginnings of basic research on the influence of blade loading and inlet boundary layer characteristics on common compressor blade profiles. The objectives of current investigations is to select critical configurations for in-depth study of the end-wall boundary layer development through the cascade with a view toward refining the experiment for use in the truly three-dimensional environment of a stator row An initial experiment on end-wall flows is outlined and typical data shown An improved technique is discussed, including test apparatus and probes to be used Other topics discussed include an interesting method of reducing secondary flow losses (partial blade slotting) and the critical analysis of a simple, but geometrically limited, theory predicting secondary flow losses at high blade loading conditions Author

N73-19812 Princeton Univ., N J
THE PREDICTION OF AXIAL COMPRESSOR PERFORMANCE WITH EMPHASIS ON THE EFFECT OF ANNULUS WALL BOUNDARY LAYERS
G L Mellor and T F Balsa *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 363-374 refs (For availability see N73-19794 10-28)

Current results are summarized in the development of a computer program to simulate axial compressor performance The program incorporates a new theory of annulus wall boundary layers which predicts annulus boundary-layer development and losses Aside from the work involved with the construction of the program, considerable effort is being expended to diagnose existing multistage data in terms of the rather simple parameters associated with the annulus boundary-layer theory Author

N73-19813 Cambridge Univ (England)
PREDICTION OF ANNULUS WALL BOUNDARY LAYERS IN AXIAL FLOW TURBOMACHINES
M Daneshyar, J H Horlock, and H Marsh *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 375-392 refs (For availability see N73-19794 10-28)

Various existing integral boundary layer methods have been examined and their predictions are compared with a wide range of experimental data The sensitivity of the boundary layer calculations to the mainstream data input has been examined Author

N73-19814 Technische Hochschule, Aachen (West Germany)
ANNULUS WALL BOUNDARY LAYERS IN AXIAL FLOW TURBOMACHINES
W Bitterlich and K Rubner *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 393-413 refs (For availability see N73-19794 10-28)

The influence of annulus wall boundary layers, which differ considerably from ordinary boundary layers, is shown as it affects the entire flow in turbomachines Starting from the measured velocity distributions, the radial balance in the axial gaps and in the cascade channel of the rotor and stator is established by means of the conservation equations for mass, momentum and energy The special effects of the transitions between stationary and moving cascades within the region of the annulus wall boundary layers are illustrated The velocity distributions measured in the boundary layer region are thus explained In contrast to what had been generally assumed, strong gradients of total enthalpy occur within the boundary layer For the blade momentum boundary values at the annulus walls and at the mean radius can be indicated, so that a qualitative distribution of blade momentum may be established The theoretical statements and results have been confirmed by experimental investigations on a single-stage axial-flow compressor having a

very small hub-tip ratio Theory and experiment show clearly that the influence of wall friction is not confined to the boundary layer region but, even with a small hub-tip ratio, affects the entire flow channel Author

N73-19815 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

RESULTS OF INTERACTION OF SHOCK WAVE WITH TURBULENT BOUNDARY LAYERS AT MODERATE MACH SUPERSONIC NUMBERS [RESULTATS SUR L'INTERACTION CHOC-COUCHE LIMITE TURBULENTE A DES NOMBRES DE MACH MODEREMENT SUPERSONIQUES]

J. Delery and J C LeBalleur *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 419-440 refs In FRENCH, ENGLISH summary (For availability see N73-19794 10-28)

Reflection of an oblique shock wave on a turbulent boundary layer was studied experimentally on a two-dimensional plane set-up at two Mach numbers, 1 62 and 1 92 In both cases the upstream flow was uniform and the Reynolds number was around 100,000 The variable parameter was the shock intensity Particular attention was paid to the set-up design for minimizing the perturbation effects and also for obtaining a good measuring precision, especially for boundary layer probings Author

N73-19816 Von Karman Inst fo Fluid Dynamics, Rhode-Saint-Genese (Belgium)

SHOCK WAVE BOUNDARY LAYER INTERACTION IN CASCADES

H Griepentrog *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 441-456 refs (For availability see N73-19794 10-28)

Experimental data obtained with compressor cascades were analyzed to determine the main parameters that affect the shock boundary layer interaction region These parameters were found to include (1) the displacement thickness of the boundary layer upstream of the shock, (2) the shock intensity, and (3) the pressure gradient downstream of the shock Taking these parameters into account, a simple model of the interaction was designed The model only considers the external effects, such as pressure distribution on the blade surface The model presented is considered only a tentative one and further research is indicated to understand the interaction of a quasi-normal shock with a turbulent boundary layer in compressor cascades D L G

N73-19817 Office National d'Etudes et de Recherches Aerospatiales, Paris (France)

BEHAVIOR OF BOUNDARY LAYER IN SUPERSONIC STRAIGHT AND ANNULAR BLADE CASCADES, FIXED AND MOBILE [COMPORTEMENT DE LA COUCHE LIMITE SUR GRILLE D'AUBES SUPERSONIQUES PLANES ET ANNULAIRES]

Jean Fabri and Roland Sovrano *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 457-468 refs In FRENCH, ENGLISH summary (For availability see N73-19794 10-28)

Fundamental research on supersonic axial flow compressors requires an accurate knowledge of section performances Straight and annular supersonic blade cascades were used for the investigation, the latter one being either fixed or rotating The effect of boundary layer development in these blade cascades is described Schlieren pictures of the flow field and shock configuration as well as pressure distributions on the blades (straight and fixed annular cascades) or on the casing (fixed and rotating annular cascades) were taken The conclusion from the analysis is that at low backpressure, i e started supersonic flow in the cascades, flow configuration and pressure distributions are very similar on all three experimental set-ups However, at high back pressure, with strong shock waves induced in the blade channel, shock wave-boundary layer interaction is quite different in static and rotating cascades It seems however that owing to the effect of centrifugal forces induced by flow rotation in the annular cascade the difference between flow patterns in this type of experimental set-up and on rotors is not very great Author

N73-19818 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany)

HIGH SPEED SCHLIEREN FILM OF THE PULSATING FLOW IN A TRANSONIC TURBINE CASCADE

O Lawaczeck *In* AGARD Boundary Layer Effects in Turbomachines Dec 1972 p 469-473 refs (For availability see N73-19794 10-28)

A high speed schlieren film is discussed that was taken in a cascade wind tunnel on a supercritical flow through a special type of a turbine cascade The flow pattern near the leading edges shows that the upstream flow is stationary although nonstationary effects were noted near the trailing edge The question is posed as to whether the nonstationary effects are initiated by the disturbances originated by the free jet boundary of the cascade or by the interaction between the trailing edge shock and the wake of the blade D L G

N73-24788# Advisory Group for Aerospace Research and Development, Paris (France).

RELATIVE AIR POLLUTION EMISSION FROM AN AIRPORT IN THE UK AND NEIGHBOURING URBAN AREAS

A W C Keddie (Dept of Trade and Ind , Stevenage, Engl), G H Roberts (Dept of Trade and Ind , Stevenage, Engl), and J Parker (Dept of Trade and Ind , Stevenage, Engl) [1971] 10 p refs Repr from the publ "Conference Pre-print No 125 on Atmospheric Pollution by Aircraft Engines" Paris, AGARD, 10 p Avail NTIS HC $3 00

Air pollution levels at Stansted Airport, England, in relation to emissions from four nearby towns are discussed Calculations have been made of pollution emissions from these four sources and also from the airport, and the expected contributions from these sources at three local sites have been examined These values are compared with actual measurements at the three sites Author

N73-26800# Advisory Group for Aerospace Research and Development Paris (France)

MODERN METHODS OF TESTING ROTATING COMPONENTS OF TURBOMACHINES

M Pianko ed (Serv Tech Aeronaut Paris) May 1973 51 p refs Partly in ENGLISH, partly in FRENCH Conf held at Toulouse, 18-21 Sep 1972

(AGARD-AG-167 AGARDograph-167) Avail NTIS HC $4 75

The AGARD Propulsion and Energetics Panel conducted a survey on the methods used to test the rotating components of turbomachines The objective was to assess the advantages and usefulness of the so called elementary tests compared with the tests conducted on complete turbomachines Based on a detailed analysis of the answers received from the questionnaires and an exchange of views among the experts appointed by the Panel, general conclusions are presented on the value and use of cascade test data testing and measuring equipment for cascade tests testing techniques for supersonic compressor cascade tests on compressor or turbine stage(s), and on a complete compressor or turbine Reynolds number effects cold testing of turbines and compressor stability and distortion tests Author

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29 SPACE RADIATION

Includes cosmic radiation, solar flares, solar radiation, and Van Allen radiation belts. For related information see also 13 Geophysics, and 24 Physics, Atomic, Molecular, and Nuclear

No abstracts in this subject category

30 SPACE SCIENCES

Includes astronomy and astrophysics, cosmology, lunar and planetary flight and exploration, and theoretical analysis of orbit and trajectory. For related information see also 11 Facilities, Research and Support, and 31 Space Vehicles.

No abstracts in this subject category

31 SPACE VEHICLES

Includes launch vehicles, manned space capsules, clustered and multistage rockets, satellites, sounding rockets and probes, and operating problems. For basic research see 30 Space Sciences. For related information see also 28 Propulsion Systems, and 32 Structural Mechanics.

N72-12861# Advisory Group for Aerospace Research and Development, Paris (France).
ATTITUDE STABILIZATION OF SATELLITES IN ORBIT
Sep 1971 152 p refs
(AGARD-LS-45-71) Avail NTIS

CONTENTS

N72-12862# Technische Hochschule Stuttgart (West Germany) Inst a fuer Mechanik
ROTATIONAL DYNAMICS
Martin A Frik *In* AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 14 p refs (See N72-12861 03-31)
Avail NTIS

The fundamentals of the rotational dynamics of satellites are considered. Basic geometric and kinematic relations are reviewed and the Euler equations describing the rotational motion of rigid bodies are derived. The torque free motion of dynamically symmetrical as well as unsymmetrical satellites is investigated including a stability analysis of permanent rotations about axes of principal moments of inertia. External torques, such as gravity-gradient, magnetic, aerodynamic, and solar radiation torques, which are caused by the interaction of an orbiting satellite with its environment, are discussed. Finally, for some types of nonrigid satellites the equations of motion are considered. Author

N72-12863*# National Aeronautics and Space Administration Goddard Space Flight Center, Greenbelt, Md
SPACECRAFT ATTITUDE SENSORS WITH EMPHASIS ON THE ORBITING ASTRONOMICAL OBSERVATORY
Thomas E Huber *In* AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 16 p refs (See N72-12861 03-31)
(NASA-TM-X-67384) Avail NTIS CSCL 22B

The sensors that provide references for the OAO control system are coarse sun sensors, fine sun sensors, Adcole aspect sensors, rate and position sensors, inertial reference unit, boresight tracker, gimbal star trackers, fixed head tracker, and magnetometers. The coarse and fine sun sensors are analog type sensors and are part of the OAO control loop. The aspect sensors are digital type and are used with the magnetometers primarily for attitude determination. The inertial sensors are used to slew or reposition the vehicle and are also used to inertially hold the spacecraft. The gimbal trackers and boresight tracker are used for stellar control holding the vehicle to an attitude accuracy of one arc minute. Author

N72-12864# Louvain Univ (Belgium) Inst de Mecanique
PASSIVE AND SEMI-ACTIVE ATTITUDE STABILIZATIONS: DUAL SPIN SATELLITES
P W Likins and P Y Willems *In* AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 11 p refs (See N72-12861 03-31)
Avail NTIS

Dual-spin systems find space applications in missions for which the ability to point some instruments or a platform with a good spin stabilization is required. The equations of motion of a deformable system including internal moments are derived. The equilibrium configurations of such a system in free space and in an inverse square field are obtained. The attitude stability of a deformable gyrostat, a convenient idealization of a dual-spin satellite, is investigated. The effect of dissipation in both sections of the system is discussed and a rigorous method permitting the stability determination is set forth. Author

N72-12865# California Univ Los Angeles
PASSIVE AND SEMI-ACTIVE ATTITUDE STABILIZATIONS: FLEXIBLE SPACECRAFT
Peter W Likins *In* AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 13 p refs (See N72-12861 03-31)
Avail NTIS

The influence of spacecraft nonrigidity is identified as the pre-emient current problem in attitude stabilization of passive and semi-active spacecraft. Attitude control anomalies in the flight histories of eight satellites are attributed to nonrigidity, manifested either as unexpected internal energy dissipation or unanticipated structural deformations. Recent progress in the development of methods for analysis of flexible spacecraft is surveyed, with attention to discrete coordinate methods, vehicle normal coordinate methods, and hybrid coordinate methods. New results are provided for each of these analytical procedures and the utility of these results is discussed in the context of anticipated future spacecraft. Author

N72-12866# Royal Aircraft Establishment, Farnborough (England) Space Dept
ACTIVE STABILIZATION
W G Hughes *In* AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 17 p refs (See N72-12861 03-31)
Avail NTIS

A survey is given of the principal devices available for the generation of control torque, covering mass expulsion systems (cold gas, hot gas, electric), momentum exchange system (reaction wheels, control moment gyros) and magnetic torquers. For reaction wheel systems the complete linearized equations of motion in three axes the effect of interaxis couplings are studied. Control in a single axis is considered in detail. Mass expulsion and magnetic techniques for momentum unloading are discussed. Control moment gyro systems are described. Pure jet systems are studied from the viewpoint of achieving high precision while preserving economy in the use of jet fuel. Difficulties arising from jet delay and sensor delay and noise are minimized by the use of a signal processing technique which incorporates a model of the spacecraft dynamics. Finally, the special properties of inertially referenced systems are considered together with the gyrocompassing technique for use in earth-pointing spacecraft. Author

N72-12867# Centre National d'Etudes Spatiales, Bretigny-Sur-Orge (France).

STABILIZATION OF EOLE AND PEOLE SATELLITES [STABILISATION DES SATELLITES EOLE ET PEOLE]

Philippe Huguier *In* AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 28 p In FRENCH (See N72-12861 03-31)

Avail NTIS

The orbits and stabilization simulations of the Eole and Peole satellites are discussed. Various methods, in particular the gravity gradient method, are discussed in detail. The accuracy of the methods was also determined. Data are included for the attenuation, energy dissipation, and the differences calculated for both satellites. Mathematical models are included.

Transl by E H W

N72-12868# Erno Raumfahrttechnik G m b H., Bremen (West Germany)

DEVELOPMENT RESULTS OF THE ESRO TD SATELLITE PNEUMATIC SYSTEM

Werner Inden *In* AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 20 p refs (See N72-12861 03-31)

Avail NTIS

The attitude control requirements and principles of the ESRO TD satellite are reviewed, and the propulsion system are explained. The TD propulsion system is an argon cold gas system with no redundant parts which is based on the life time of 1/2 to 1 year in orbit. The test results of development, qualification, and flight acceptance are illustrated as the influence of the dynamic response on thrust, the problem of leakage and contamination, the regulation as a function of mission time. The successful subsystem qualifications, especially vibration tests, are shown. Development techniques for nozzles, system filling and leakage checkout are described. The performance of the small nozzles (0.02 N) used on TD is shown.

Author

N72-12869# Compagnia Industriale Aerospaziale S.p.A., Rome (Italy).

THE SIRIO ATTITUDE MEASUREMENT AND CONTROL SYSTEM

Alessandro Buratti *In* AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 14 p (See N72-12861 03-31)

Avail NTIS

The Sirio attitude measurement and control subsystem components, their characteristics, their interconnection with other units, their mode of operation and how they are employed are described. Component test problems are discussed where appropriate, as in the case of the sensors and of the nutation damper. Emphasis is given to attitude measurement and an estimate of the accuracy which may be achieved both in the transfer and in the geostationary orbit is given.

Author

N72-12870# Massachusetts Inst. of Tech., Cambridge. Charles Stark Draper Lab.

ATTITUDE CONTROL OF THE APOLLO SPACECRAFT

Richard H Battin *In* AGARD Attitude Stabilization of Satellites in Orbit Sep 1971 10 p refs (See N72-12861 03-31)

Avail NTIS

The digital computer is the central control element in the Apollo control guidance and navigation system. The primary autopilots of the various spacecraft configurations of Apollo are implemented digitally in this general purpose processor. Successful control system design was made possible by capitalizing on the nature of digital processing and exploiting the attendant flexibility and nonlinear computability. After a brief description of the control system hardware, a detailed treatment of one of these autopilots, coasting flight attitude control is given.

Author

N73-23881# Advisory Group for Aerospace Research and Development, Paris (France).

AUTOMATION IN MANNED AEROSPACE SYSTEMS

Mar 1973 322 p refs In ENGLISH and partly in FRENCH Presented at 24th Tech. Meeting of the Avionics Panel of AGARD, Dayton, Ohio, 16-19 Oct. 1972

(AGARD-CP-114) Avail NTIS HC $18.25

Functional analyses of manned aerospace systems for the design of automatic avionic equipment are reported. Onboard computer capabilities to perform decision making functions, adaptive control, malfunction detection and compensation, real-time control are considered. For individual titles, see N73-23882 through N73-23905.

N73-23882 Massachusetts Inst. of Tech., Cambridge.

MAN'S ROLE IN INTEGRATED CONTROL AND INFORMATION MANAGEMENT SYSTEMS

J. L. Nevins and I. S. Johnson *In* AGARD Automation in Manned Aerospace Systems Mar. 1973 7 p refs (For availability see N73-23881 14-31)

An information processing and data management system is reported that relieves man's role in such tasks as pre-flight subsystem checkout and periodic system status checks. The prototype generalized display and command technique outlined features a pushplate interactive control scheme with graphic display in connection with an airborne computer.

G.G.

N73-23883 Office National d'Etudes et de Recherches Aerospatiales, Paris (France).

GENERAL GUIDELINE FOR THE DESIGN OF MANNED AEROSPACE VEHICLES

Jean-Claude Wanner *In* AGARD Automation in Manned Aerospace Systems Mar. 1973 8 p refs (For availability see N73-23881 14-31)

The Franco-British airworthiness authorities reviewed the set of technical specifications required for Concorde in order to insure the safety of the missions of this new transport aircraft. In order to guide the definition of these new regulations, a theoretical method was developed for evaluating the reliability of the missions of manned aerospace vehicles. This method is based on an investigation of the way of occurrence of accidents. It has been seen that an accident is due to a set of incidents which can be classified into only three different types. The study of each type of incident, the probability of occurrence which has to be reduced in order to increase the safety, is very useful to help the designer of a new project to choose between possible solutions taking into account the reliability of the systems, the possible human errors and the flight conditions.

Author

N73-23884 Grumman Aerospace Corp., Bethpage, N.Y.

THE INFLUENCE OF COST AND TECHNICAL RISK ON THE DESIGN OF THE AVIONICS SYSTEM FOR THE SPACE SHUTTLE

Howard T Wright *In* AGARD Automation in Manned Aerospace Systems Mar 1973 9 p (For availability see N73-23881 14-31)

The evolution of the Space Shuttle Program from its inception to the release of the request for proposal in April of 1972, has been influenced primarily by cost considerations. Various configurations were studied, and cost pre-flights were traded against developmental cost. These studies indicated operational costs between 4.5 million and 15.8 million dollars per flight. The baseline configuration was based on the best competition between development and operational cost considerations. The configuration selected was a small orbiter vehicle with an external hydrogen and oxygen tank and two solid rocket engines. This configuration results in operational cost per flight of approximately 11 million dollars.

Author

N73-23885 Northrop Corp., Palos Verdes Peninsula, Calif.

AUTOMATIC ACQUISITION AND TRACKING METHODS EMPLOYED IN THE JOINT SERVICES IN-FLIGHT DATA TRANSMISSION SYSTEM (JIFDATS)

T. N. Leiboff *In* AGARD Automation in Manned Aerospace Systems Mar 1973 21 p (For availability see N73-23881 14-31)

JIFDATS is an all-weather, day-night, multi sensor in-flight data transmission system designed for use by all the military services. The normal operating mode for JIFDATS is automatic. Except for the usual checkout, servicing and maintenance activities in which personnel take a large part, the only need for personnel functions is to establish the proper conditions for system operation, turn on the system, and monitor the operation to

assure continuity of data transmission In each case though, there is a manual back-up mode for bypassing the automatic features of acquisition and tracking. A scenario of a typical tactical reconnaissance mission is presented showing the various steps taken by the operator in the sensor aircraft, the operator in the relay aircraft, and personnel at the surface terminal during each phase of the mission. It is shown how the relay aircraft automatically acquires the sensor aircraft which is transmitting a low bandwidth signal on an omni-directional antenna, while it rotates its high-gain narrow beam directional antenna. The sensor aircraft locks on to the relay while the relay and ground terminals acquire and track. Author

N73-23886 Consiglio Nazionale delle Ricerche, Genoa (Italy).
DETERMINATION OF AN OPTIMAL TRAJECTORY IN THE PRESENCE OF RISK
A Tiano, P Dagnino, and M Piattelli *In* AGARD Automation in Manned Aerospace Systems Mar 1973 19 p refs (For availability see N73-23881 14-31)

A controlled dynamic system is considered that displaces within an assigned space, where r moving targets are contained. An optimal control sequence transfers the system from an initial point to a preset terminal point so that the optimal trajectory is the one which, complying with some safety constraints imposed by the targets, minimizes a given cost function. Assuming that the system may be supplied with periodical information about the motion of the targets, a numerical algorithm utilizing a dynamic programming procedure is determined. This procedure is applied to two practical problems (1) Marine anticollision aided by computerized radar systems in the presence of N targets, and (2) determination of an optimal evasion strategy in the presence of cyclonic disturbances Author

N73-23887 North American Rockwell Corp, Downey, Calif. Space Div
SPACE STATION INFORMATION SYSTEM REQUIREMENTS: A CASE HISTORY OF MAN-MACHINE SYSTEM DEFINITION
C R Gerber *In* AGARD Automation in Manned Aerospace Systems Mar 1973 8 p (For availability see N73-23881 14-31)

The NASA space station definition studies incorporate a multiplicity of automated supporting functions to enhance the useful work capability of very few men. The SS information system is the means by which the men interface with all subsystems, space experiments, other vehicles, ground support facilities and personnel. It is therefore a driver in determining what program and mission objectives can be satisfied. The study resulted in the definition of an information subsystem consisting of a unique combination of multi-processing computation, internal data distribution via a digital data bus, crew interfacing via a set of multi-purpose display and control consoles, and external data distribution via a combination of VHF, S and K band RF links Author

N73-23888* International Business Machines Corp, Houston, Tex Federal Systems Div
AUTOMATED TECHNIQUES FOR SPACECRAFT MONITORING
H Richard Segnar *In* AGARD Automation in Manned Aerospace Systems Feb 1972 12 p refs Sponsored by NASA (For availability see N73-23881 14-31)
CSCL 22B

The feasibility of implementing automated spacecraft monitoring depends on four factors sufficient computer resources, suitable monitoring function definitions, adequate spacecraft data, and effective and economical test systems. The advantages of automated monitoring lie in the decision-making speed of the computer and the continuous monitoring coverage provided by an automated monitoring program. Use of these advantages introduces a new concept of spacecraft monitoring in which system specialists, ground based or onboard, freed from routine and tedious monitoring, could devote their expertise to unprogrammed or contingency situations Author

N73-23889 Saab Aircraft Co., Linkoping (Sweden). Systems and Avionics Dept
SOME DEVELOPMENT TRENDS IN THE INTEGRATION OF ELECTRONIC SYSTEMS IN THE SWEDISH AIRCRAFT 37 VIGGEN
Bengt Sjoebert *In* AGARD Automation in Manned Aerospace Systems Mar 1973 8 p (For availability see N73-23881 14-31)

The Swedish 37 VIGGEN aircraft is being developed in several versions and the electronic systems of the attack version and the later fighter version are compared and some development trends are discussed. An increased role of the central computer is recognized as well as a trend towards digitalization of several subsystems. Author

N73-23890 Aeritalia, Turin (Italy)
MULTILOOP ATTITUDE CONTROL SYSTEM FOR A SATELLITE WITH FLEXIBLE BOOMS
R DiLorenzo and E DeBernardis *In* AGARD Automation in Manned Aerospace Systems Mar 1973 13 p refs (For availability see N73-23881 14-31)

A class of momentum exchange devices control configurations has been considered, namely that which provide a momentum quite larger along one body axes rather than along the other ones. The general equations of a satellite controlled in such a way have been used in order to provide a control system which is independent from the particular devices used, these equations have been modified in order to take into account that the satellite has a couple of flexible booms. A simple multiloop controller has been designed for such equations, and it is shown that to adapt it to each particular actuators configuration it is only necessary to design three very conventional inner control loops. Finally, a simulation of the full flexible systems has been made using FORTRAN 5, with reasonable numerical values of the satellite dynamics parameters, where it is shown that a controller designed considering rigid the whole satellite results either in instability or very degraded pointing accuracy Author

N73-23891* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala
OPTIMUM SPACEBORNE COMPUTER SYSTEM DESIGN BY SIMULATION
T Williams (Computer Sci Corp, Huntsville, Ala), H Kerner, J L Weatherbee (Computer Sc Corp, Huntsville, Ala), D S Taylor (Computer Sci Corp., Huntsville, Ala), and B Hodges *In* AGARD Automation in Manned Aerospace Systems Mar 1973 12 p refs (For availability see N73-23881 14-31)
CSCL 09B

A deterministic simulator is described which models the Automatically Reconfigurable Modular Multiprocessor System (ARMMS), a candidate computer system for future manned and unmanned space missions. Its use as a tool to study and determine the minimum computer system configuration necessary to satisfy the on-board computational requirements of a typical mission is presented The paper describes how the computer system configuration is determined in order to satisfy the data processing demand of the various shuttle booster subsytems The configuration which is developed as a result of studies with the simulator is optimal with respect to the efficient use of computer system resources Author

N73-23892 Consiglio Nazionale della Ricerche, Pisa (Italy) Ist di Elaborazione dell Informazione
EXTENSION OF SIMULA 67 FOR PROCESS CONTROL
Juliusz H. Kardasz *In* AGARD Automation in Manned Aerospace Systems Mar 1973 13 p refs (For availability see N73-23881 14-31)
Copyright

An extension of SIMULA 67 towards process control is reported The extension is prepared with an idea of using it to control large systems of interconnected devices where the necessity for real time simulation arises, in order to define a future behaviour of the system This extension combines both characteristics of procedural and fill-in-the-blank (format oriented) languages The programming requirements for process control

applications are discussed and a comparison is made between some algorithmic languages with respect to the degrees in which they meet these requirements. This discussion shows that SIMULA 67 requires the introduction of less new concepts than other languages in order to be extended for process control. These new concepts include first of all the interface with a process which is introduced by an external class to be implementation defined. A procedural language is used for constructing the body of the system, composed of procedures and classes.
Author

N73-23893* National Aeronautics and Space Administration. Lyndon B Johnson Space Center, Houston, Tex.
SYSTEMS PERFORMANCE MONITORING FOR ADVANCED MANNED SPACECRAFT
T V Chambers *In* AGARD Automation in Manned Aerospace Systems Mar 1973 16 p refs (For availability see N73-23881 14-31)
CSCL 22B

Optimum system mechanizations for advanced manned spacecraft are considered. Several studies have proposed automation of the onboard system management task, with functions such as system status monitoring, configuration management, and redundancy management being accomplished under computer control. An experimental system was used in the laboratory to investigate hardware and software requirements for accomplishing these onboard system management functions. A performance monitor system is proposed for the space shuttle. This system provides support to the flight crew in the management of all onboard systems but does not perform critical switching functions during the flight phase.
Author

N73-23894 Selenia S.p.A., Rome (Italy)
A GENERAL PURPOSE COMPUTER FOR SPACEBORNE APPLICATIONS
S Bcesso and R Camberale *In* AGARD Automation in Manned Aerospace Systems Mar 1973 18 p (For availability see N73-23881 14-31)

A modular expandable computer system is studied for a wide range of possible space missions. The main goals in designing the computer have been maximum flexibility and reliability, minimum weight and power consumption and growth capability to fit future mission requirements. The study resulted in a stored program, 16 bit, parallel machine, with microprogrammed control which allows full arithmetic and logic capability. Input-output includes program-controlled and direct-memory-access channels. The main points of trade-off for system design are presented and a description of the basic computer units at the functional block level is given.
Author

N73-23895 Societe Nationale Industrielle Aerospatiale Paris (France)
INERTIALESS FLIGHT METHODS [PROCEDE DE SURVOL NON INERTIEL]
P J Bigeon, J Langlois, and R Berrqir *In* AGARD Automation in Manned Aerospace Systems Mar 1973 19 p In FRENCH (For availability see N73-23881 14-31)

An automatic inertialess flight control and guidance system is reported that determines aircraft position by precisely calculating actual flight course deviation for telemetric guidance correction. An onboard computer processes data from a platform containing directional and vertical gyroscopes, from an automatic pilot, and from an atmospheric pressure sensor.
Transl by G G

N73-23896 Royal Aircraft Establishment, Farnborough (England)
THE EXPERIMENTAL EVALUATION OF AUTOMATED NAVIGATION SYSTEMS
J G Carr *In* AGARD Automation in Manned Aerospace Systems Mar 1973 13 p (For availability see N73-23881 14-31)

Certain aspects of automated avionics systems which are being examined in the RAE Comet exercise are described. The emphasis is on navigation systems and includes the work on digital computers and on-board digital communication techniques, software developments including the use of high level programming languages, and the use of computer controlled electronic displays. The laboratory work using simulated navigation sensor inputs into an experimental system comprising a digital computer and electronic displays is described. A Comet 4 aircraft has been re-equipped as a flying laboratory for this work. The installation in the cabin of the aircraft and some of the current experimental investigations are described. The cockpit of the Comet has also been modified by the addition of experimental electronic displays to the second pilot's instrument panel.
Author

N73-23897 Systems Control, Inc., Palo Alto, Calif.
CURRENT STATUS OF MODELS FOR THE HUMAN OPERATOR AS A CONTROLLER AND DECISION MAKER IN MANNED AEROSPACE SYSTEMS
A. V. Phatak and D. L. Kleinman *In* AGARD Automation in Manned Aerospace Systems Mar. 1973 10 p refs (For availability see N73-23881 14-31)

Mathematical models of human decision processes and adaptive behavior have been proposed for specific control situations. Accepted techniques and models for analyzing and predicting human performance in complex multi-control and multi-display situations commonly found in aerospace systems are surveyed. The models have been developed or proposed for the related human functions of information processing, decision making and control. The relative advantages, disadvantages and limitations of each of the modeling schemes are discussed and prospects for mechanizing all or part of the decision functions performed by human operators are considered, specific examples being in the automation of human failure detection and adaptation to sudden changes in the system operating conditions.
Author

N73-23898 Royal Aircraft Establishment, Bedford (England)
MANUAL LANDING IN FOG
R. R. Newbery *In* AGARD Automation in Manned Aerospace Systems Mar 1973 19 p refs (For availability see N73-23881 14-31)

The results of 18 fog flying sorties using a Category II operation terminated by a manual landing have been analyzed in an attempt to learn more about the pilot's capabilities in this environment. Measurements were made to correlate the pilot's decision making process with actual fog structures in real operation. A wide variety of fog structure and visual sequences are illustrated which demonstrate the lack of relationship between the visual segment at high decision heights, the height at which visual contact is first made and the runway visual range measurement. The pilots felt that Category II operation was straightforward provided that good quality approach performance, strict crew drills a accurate RVR reporting to give warning of shallow or changing fog conditions along the runway, were maintained.
Author

N73-23899 Aerospace Medical Research Labs., Wright-Patterson AFB, Ohio
MONTE CARLO SIMULATION OF DEGRADED MAN-MACHINE PERFORMANCE
Gerald P Chubb *In* AGARD Automation in Manned Aerospace Systems Mar 1973 11 p refs (For availability see N73-23881 14-31)

System vulnerability is a function of both human and hardware vulnerabilities to anticipated threat environments. The feasibility of considering the interaction of man and machine degradation under nuclear attack conditions has recently been demonstrated. It appears that the technique may be useful in identifying certain situations where automation may be particularly useful under these attack conditions, although the requirement is not obvious from analyses of system performance under nominal operating conditions. The approach taken appears generalizable to other degradation conditions, such as inflight malfunctions and conventional weapons battle damage. Given suggested changes in man-machine task sequencing, the model can aid in assessing how these changes may affect selected systems effectiveness measures. A number of refinements and extensions to the current capabilities of this model are envisioned and briefly discussed.
Author

N73-23900 Marconi-Elliott Avionic Systems Ltd., Rochester (England)
DEVELOPMENTS IN AIRCRAFT DIGITAL SYSTEMS
R. Ruggles and E. M. Scott *In* AGARD Automation in Manned Aerospace Systems Mar. 1973 11 p (For availability see N73-23881 14-31)

The effects of the relationship between user need and technological capability are considered for flight control as opposed to navigation and some physical characteristics of current digital autopilots are given. The functional division and integration of avionic subsystems are considered and it is concluded that integration in the form of loosely federated groups of related systems is preferred to the centralized computer complex in spite of its apparent conceptual simplicity. The concept of task oriented computers is discussed and the main parameters of some existing examples are given. Some details of the architecture, software and hardware for this type of computer are given. An example of the application to automatic flight control with a requirement for a fail operative capability is given and the problem of dealing with tolerances between operating lanes is briefly discussed. Author

N73-23901 Hawker Siddeley Aviation, Ltd., Hatfield (England)
HUMAN FACTORS IN LOW WEATHER OPERATION OF TRANSPORT AIRCRAFT
J. W. Wilson *In* AGARD Automation in Manned Aerospace Systems Mar. 1973 5 p (For availability see N73-23881 14-31)

Practical experience gained during the manufacturer's flight development testing and airline in-service operation of a failure-survival Category 3 automatic landing system is reviewed for indications of the extent to which human factors have affected the design of the system and the techniques used by the airline in order to reach the very high safety levels that are necessary. The important factors influencing the complexity of the task are (1) Provision of adequate monitoring devices located in the optimum area of each crew member's primary visual scan, to enable the pilot to keep ahead of the operation of the automatic control systems, (2) application of identical procedures for use in Category 1, 2 or 3 weather, (3) design of the system and development of procedures such that the maximum number of manual and automatic functions that require action, checking or monitoring can be completed before the final stage of the approach to land, and (4) the decision to land should be made as low as possible, compatible with a go-around performance which will not normally result in touchdown. Author

N73-23902 Air Force Systems Command, Wright-Patterson AFB, Ohio. Airborne Computer Engineering Branch
AVIONIC SYSTEMS INTEGRATION USING DIGITAL COMPUTERS
Erwin C. Gangl *In* AGARD Automation in Manned Aerospace Systems Mar. 1973 5 p (For availability see N73-23881 14-31)

Present weapon systems use a multiplicity of signal formats and transmission techniques for information transfer within an integrated avionics system. The implementation of a serial digital data bus as the primary means of functionally communicating and interconnecting the various equipments is described. If a system is logically partitioned to the data it supplies, requires or processes, then with a flexibly designed digital data bus and standard interfaces, it can easily be integrated through the computer software. Modification or redesign of the multiplexed data bus concept is a matter of reconfiguration of the building blocks, adding and deleting as required and then changing the software to reintegrate the new configuration, saving the costly rewiring and redesigning of the computer converter box. The computer is now a separate line replaceable unit, not subject to obsolescence due to systems modifications. Author

N73-23903 Smiths Industries, Ltd., Cheltenham (England). Aviation Div.
THE EXPONENTIAL PROBABILITY DISTRIBUTION AND ITS USE IN ASSESSING THE PERFORMANCE STATISTICS OF AEROSPACE SYSTEMS
D. A. Lloyd *In* AGARD Automation in Manned Aerospace Systems Mar. 1973 31 p refs (For availability see N73-23881 14-31)

The statistics of the output state variables of automatic aerospace systems are of considerable interest and of wide application, particularly in the case of manned systems. The paper shows that the exponential probability distribution can be used as an approximation to the distributions of the output state variables of practical aerospace systems for a wide range of practical situations. The use of the exponential distribution as a practical mathematical tool is suggested in the assessment of some of the performance statistics of aerospace systems both for preliminary calculations and for final calculations involving the extrapolation of test results. Author

N73-23904* National Aeronautics and Space Administration, Washington, D.C.
POTENTIAL TELEOPERATOR APPLICATIONS IN MANNED AEROSPACE SYSTEMS
Edwin G. Johnsen *In* AGARD Automation in Manned Aerospace Systems Mar. 1973 [illegible] p refs (For availability see N73-23881 14-31)
CSCL 05H

The trend of teleoperator development is toward digital computer controlled systems which utilize local sensor-computer-actuator loops to avoid obstacles and to sense manipulator grip-and-slip. The potential applications of advanced teleoperator technology to manned aerospace systems include long manipulator booms to be mounted on the shuttle. These can transfer cargo from the space shuttle and can acquire and retrieve objects in space. Free-flying teleoperators capable of acquiring, inspecting, repairing or refurbishing satellites in orbit are another space application. Another potential application of teleoperator technology is the concept of using an anthropomorphous teleoperator in lieu of man to control aircraft or spacecraft normally controlled by a human pilot. Author

N73-23905 Boeing Co., Seattle, Wash.
MAN-MACHINE CONSIDERATIONS IN THE DEVELOPMENT OF A COCKPIT FOR AN ADVANCED TACTICAL FIGHTER
S. Joel Premselaar and D. E. Frearson (AFFDL) *In* AGARD Automation in Manned Aerospace Systems Mar. 1973 20 p (For availability see N73-23881 14-31)

A revolutionary cockpit concept for a 1975-85 one-man, multi-mission fighter aircraft completed an initial simulation phase recently. The design goal of this concept is to achieve a one-man workload level by presenting the pilot only the information necessary for the particular mission segment he is performing, and yet provide maximum flexibility in terms of pilot options. Key elements of the cockpit design are: Multiple, time-shared electronic displays, keyboard and voice command computer input devices, wrap-around cockpit arrangement for ease of access to the control-display devices, an integrated total energy command, and a system of dependent automation that permits reduced pilot workload during anomalies. The simulator provides a one-of-a-kind capability for examination of the flight deck design issues involved in tailoring the power and flexibility of the computer to the capabilities and limitations of the human pilot in the performance of his mission. Author

32 STRUCTURAL MECHANICS

Includes structural element design and weight analysis fatigue thermal stress impact phenomena vibration flutter inflatable structures and structural tests For related information see also 17 Materials Metallic and 18 Materials Nonmetallic

N71-20128# Advisory Group for Aerospace Research and Development Paris (France)

STRUCTURAL DESIGN APPLICATIONS OF MATHEMATICAL PROGRAMMING TECHNIQUES

G G Pope and L A Schmit eds Feb 1971 203 p refs (AGARD-AG-149-71 AGARDOGRAPH-149) Avail NTIS

CONTENTS

N71-20129# Advisory Group for Aerospace Research and Development Paris (France)

INTRODUCTION AND BASIC CONCEPTS

L A Schmit and G G Pope *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 2 13 refs (See N71 20128 09 32)

Avail NTIS

The application of mathematical programming methods to aerospace structural design is discussed The fundamental ideas are illustrated by considering the elementary examples of a simply supported column and a two bar truss The traditional approach to least weight design of aircraft structures is stated to be formulating the optimization problem in terms of equations and a variation is the reduction of the objective function to one of a single variable Terminology used in mathematical programming is defined and the main features in applying the techniques to structural design are outlined Mathematical programming techniques applied to materials selection is usually characterized by a discrete set of available materials even for composite materials N E N

N71-20130# Advisory Group for Aerospace Research and Development Paris (France)

A BASIS FOR ASSESSING THE STATE OF THE ART

L A Schmit *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 14 29 refs (See N71-20128 09 32)

Avail NTIS

The design philosophy in combining computer oriented structural analysis with mathematical programming methods is described One approach to the problem is to design the structure so that initial yielding under service load conditions is avoided and another is to design so as to prevent collapse under service load conditions Design variables and weight minimization as the objective function are described Formulations are discussed and include sequence of linear programs sequence of unconstrained minimizations basic nonlinear programming and classical formulation of the inequality constrained minimization problem N E N

N71-20131# Advisory Group for Aerospace Research and Development Paris (France)

CLASSICAL OPTIMIZATION THEORY RELEVANT TO THE DESIGN OF AEROSPACE STRUCTURE

G G Pope *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 30 33 refs (See N71 20128 09 32)

Copyright Avail NTIS

Design optimization of aerospace structures which must behave elastically under service conditions is discussed The classical theorem which is applicable directly to the least weight design of highly idealized frameworks is emphasized It is assumed that the structure is fabricated from an elastic perfectly plastic material and the basic theory for single and multiple load conditions is given The optimum layout of least weight elastic frameworks and general properties are described N E N

N71-20132# Advisory Group for Aerospace Research and Development Paris (France)

LITERATURE REVIEW AND ASSESSMENT OF THE PRESENT POSITION

L A Schmit *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 34 45 refs (See N71 20128 09 32)

Avail NTIS

A selective review of articles on mathematical programming applications to structural design optimization limited to finite problems is presented An effort is made to trace the development of programming applications and papers thought to have strongly influenced this development are discussed Current and future trends are also described and brief reviews are given on structural optimization in the dynamic response regime and reliability based structural optimization N E N

N71-20133# Advisory Group for Aerospace Research and Development Paris (France)

SEQUENCE OF LINEAR PROGRAMS

G G Pope *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 48 54 refs (See N71 20128 09 32)

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The reduction of nonlinear programming problems to a sequence of linear programming problems is discussed Important properties of linear programming problems and methods of their solution are described In nonlinear programming problems considered first are those in which all constraints are expressed as inequalities and in which only two variables are involved Methods of reducing the nonlinear problems are outlined The simplest approach linearizes the constraints and merit function in the neighborhood of an arbitrary point The cutting plane method

employs the property that linearized constraints in convex problems necessarily lie entirely outside the feasible region. The move limit method makes use of artificial limits on the variation of the design variables in a typical linearized computation. In all of these methods, the coefficients of the design variables in the objective function of the primal problem are nearly always all positive. N E N

N71-20134# Advisory Group for Aerospace Research and Development Paris (France)
UNCONSTRAINED MINIMIZATION APPROACHES TO CONSTRAINED PROBLEMS
R L Fox *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 55 78 refs (See N71-20128 09 32)
Avail NTIS

Several unconstrained minimization methods are discussed and their advantages and disadvantages are presented. The basic idea of these methods is to convert the constrained problem, with its objective function and equality and inequality constraints, into a problem in which some new function is minimized without regard for constraints. The solution to the original problem is developed through a sequence of unconstrained minimizations. The reliability of the algorithms, their sequential nature, and the straightforward formulation and implementation of these methods are described. Formulations employing interior penalty functions are discussed in order to apply the unconstrained minimization methods to the solution of the constrained problem. Formulations employing exterior penalty functions, and penalty functions for equality constraints are also mentioned. N E N

N71-20135# Advisory Group for Aerospace Research and Development Paris (France)
FEASIBLE DIRECTION METHODS
J S Kowalik *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 79 93 refs (See N71-20128 09 32)
Avail NTIS

Algorithms for solving a general nonlinear programming problem and which have proved to be successful and applicable to structural optimization problems are discussed. The advantages and disadvantages of the methods are compared from theoretical and computational viewpoints. Zoutendijk's usable feasible directions method efficiently reduces the problem to a sequence of linear programming problems, is finite for quadratic programming problems and can handle nonconvex problems. A modified feasible directions method utilizes some ideas of the cutting plane method. Rosen's gradient projection method uses projections of the objective function gradient into the manifold defined by currently active constraints. The method works with vectors which are feasible and usable and replaces linear optimization subproblems with matrix inversion schemes. Gellatly's optimum vector method determines the direction of search from a set of simultaneous linear equations which can be solved by the stable Choleski decomposition method. N E N

N71-20136# Advisory Group for Aerospace Research and Development Paris (France)
COMPUTER PROGRAMS FOR THE OPTIMUM DESIGN OF COMPLEX ELASTIC STRUCTURES
G Pope *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 96 101 refs (See N71-20128 09 2)
Copyright Avail NTIS

Computer programs developed for the optimum design of idealized aerospace structures of arbitrary geometry including optimization algorithms and segments for finite element analysis are described. These programs are concerned mainly with the choice of member cross sectional areas and thicknesses but some include facilities which permit the lengths and spacings of members to be varied within a prescribed topology. Rigorous optimization procedures are emphasized. Computer programs developed to apply mathematical programming techniques to the least weight design of complex stress skin structures and major subsequent contribution are discussed. Application of iterative procedures for the generation of fully stressed designs is also described. Author

N71-20137# Advisory Group for Aerospace Research and Development Paris (France)
SPECIAL PURPOSE APPLICATIONS
L A Schmit *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 102 123 refs (See N71-20128 09 32)
Avail NTIS

A few examples of mathematical programming applications to specific structural design problems are described. The examples discussed point up the important role structural optimization can play in evaluating alternative design concepts and materials based upon a comparison of optima. The stiffened cylindrical shell optimization capability is reviewed in some detail. The extension of this capability to shells with slight meridional curvature is briefly discussed and two recently reported special purpose applications to fiber composite structures are noted. Application of an integrated penalty function approach to the optimum design of an ablating composite type heat shield is described. Author

N71-20138# Advisory Group for Aerospace Research and Development Paris (France)
OPTIMIZATION OF STRUCTURES WITH RELIABILITY CONSTRAINTS
F Moses *In its* Structural Design App of Mathematical Programming Tech Feb 1971 p 126 143 refs (See N71-20128 09 32)
(Grants NSF GK-74 NSF GK-1871)
Avail NTIS

The relationship between optimum design of structure as it is now formulated in almost classical terms and reliability or safety of structures is studied. The kinds of structures for which reliability or failure probability can reasonably be analyzed and have been presented particularly in a redesign or optimization procedure are discussed. As the topic concerns safety in a probabilistic framework some attention is given to relevant questions of probability sensitivity, failure costs, limited empirical information, analysis errors, and safety philosophy. Several examples of optimization with reliability or failure probability constraints are presented. Author

N71-20139*# Advisory Group for Aerospace Research and Development Paris (France)
OPTIMIZATION UNDER AEROELASTIC CONSTRAINTS
H Ashley S C McIntosh Jr and W H Weatherhill *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 144 173 refs Sponsored by NASA and the AF (See N71-20128 09 32)
(NASA CR-117198) Avail NTIS CSCL 20K

Two major lines of development in the optimization of aeroelastic constraints for high performance aircraft design are discussed. The optimization of problems with one dimensional space variable can be identified as a variational problem and reduced to systems of first order ordinary differential equations. Discretization by assumed-mode and finite element methods are also described and the control variables are replaced with a finite vector of n adjustable element properties. Minimization of the chosen merit function amounts to a search of n vectorspace. Mathematical discussions of examples are given for each method and the importance of each method in future development is indicated. N E N

N71-20140# Advisory Group for Aerospace Research and Development, Paris (France)

OPTIMIZATION TECHNIQUES IN AIRCRAFT CONFIGURATION DESIGN

B Silver and H Ashley *In its* Structural Design Appl of Mathematical Programming Tech Feb 1971 p 174 194 refs (See N71-20128 09-32)

Avail NTIS

Parametric analysis and automated search methods for preliminary design optimization are compared, and methods of optimization that go beyond parametric analysis are investigated. Indirect methods, such as the calculus of variations, are mentioned. Direct methods of optimization are discussed including selection of design variables, constraint formulation, methods with and without derivatives, one dimensional search methods, and convergence criteria. The indirect methods solve auxiliary problems, while the direct methods adopt a hill-climbing strategy on the objective function directly. Operational results of direct search methods are given, and the field of man-computer interactive design is briefly described NEN

N71-25449# Advisory Group for Aerospace Research and Development, Paris (France)

COOPERATIVE CREEP TESTING PROGRAMME

D Coutsouradis (Centre Natl de Rech Met) and D K Faurschou (Dept of Energy Mines and Resources) Mar 1971 100 p refs (AGARD R 581 71 Avail NTIS

The Advisory Group for Aerospace Research and Development (AGARD) initiated an interlaboratory study of high temperature creep testing facilities and techniques. The program utilised factorial design and analysis. Nimonic 105 was tested at 900 C by eighteen voluntary laboratories. The results have permitted statistical evaluation of intra and interlaboratory variability and the significance of some testing and material variables which affect creep results. Author

N72-13982# Advisory Group for Aerospace Research and Development, Paris (France)

THE ELEMENTS OF FRACTOGRAPHY

D A Ryder (Manchester Univ) Nov 1971 196 p refs (AGARD-AG-155-71, AGARDograph-155) Avail NTIS

This monograph is intended to serve as an introduction to Fractography which may be defined as the examination of fracture surfaces at magnifications ranging from x1 to x100,000. The terminology and current ideas on fracture are introduced in an elementary account of those factors that control the mechanical properties of engineering materials. Fracture is discussed in general terms and the instruments available for fracture surface analysis are considered. The experimental and operational techniques needed in fractography are discussed with a variety of factors, especially artefacts in replicas prepared for transmission electron microscopy, that can influence the interpretation of experimental results. The application of fractography to the investigation of service failures and the use of the technique in fracture research are described Author

N72-21900# Advisory Group for Aerospace Research and Development, Paris (France)

SPECIALISTS MEETING ON STRESS CORROSION TESTING METHODS

Jan 1972 332 p refs Presented at Struct and Mater Panel 33d Meeting, Brussels, 5-6 Oct 1971

(AGARD-CP-98) Avail NTIS HC $6.00/MF $0.95

The basic objectives of the Specialists Meeting were to discuss (1) the utility and significance of stress corrosion cracking data to current engineering and design practices, (2) the progress being made NATO countries toward standardization of test techniques for stress corrosion cracking, and (3) those test methods which might be recommended as standard techniques in the immediate future. Also included are the types and quality of data which are useful in design analysis, the attitudes and activities of various corrosion and fracture committees in the U.S. and Europe toward standardization techniques, and summaries of stress corrosion cracking and test equipment used to measure corrosion in various materials, aircraft structures, and space shuttle designs. For individual titles, see N72-21901 through N72-21931.

N72-21901# Battelle-Northwest, Richland, Wash. Pacific Northwest Labs.

ENGINEERING UTILITY AND SIGNIFICANCE OF STRESS CORROSION CRACKING DATA

W. E. Anderson *In* AGARD Specialist's Meeting on Stress Corrosion Testing Methods Jan. 1972 23 p refs (See N72-21900 12-32)

Avail NTIS HC $6.00/MF $0.95

Some historical experiences with cracking and fracture problems are explored to indicate the significance of corrosion acting concomitantly with stress. These experiences suggest that cracks develop either in 'open' or 'closed' areas; and, either at regions accessible to the ambient environment and direct view, or at regions which are structurally hidden. Special attention was given to aircraft structures and various other materials. Data cover specimen configurations, methods suitable for low cost testing of specimens, and estimates of service life under loading and environmental conditions. A definition of stress corrosion is included. Author

N72-21902# Reynolds Metals Co., Richmond, Va. Metallurgical Research Div.

PROGRESS TOWARD STANDARIZATION OF SCC TEST TECHNIQUES BY THE AMERICAN SOCIETY FOR TESTING AND MATERIALS

H Lee Craig, Jr *In* AGARD Specialist's Meeting on Stress Corrosion Testing Methods Jan 1972 10 p (See N72 21900 12-32)

Avail NTIS HC $6.00/MF $0.95

The work of a subcommittee on test standards for stress corrosion of metals and other materials is presented. The committee covers (1) smooth specimens and test jig, (2) test environments and specific material tests, (3) corrosion fatigue and (4) precracked specimens Author

N72-21903# Aluminum Co of America, Pittsburgh, Pa Chemical Metallurgy Div

PROGRESS TOWARD STANDARDIZATION OF SCC TEST TECHNIQUES BY THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS AND THE ALUMINUM ASSOCIATION c14

Donald O Sprowls *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 20 p (See N72 21900 12-32)

Avail NTIS HC $6.00/MF $0.95

The stress corrosion testing of high strength, heat treatable aluminum alloys is discussed. Three tempers of alloy 7075 was laboratory tested for the purposes of (1) comparing three types of smooth test specimens, (2) ascertaining the uniformity of test results that can be expected with a closely controlled procedure for the 3.5% NaCl alternate immersion test, (3) evaluating other corrodents that do not cause severe pitting of these alloys, and (4) relating the SCC (stress corrosion cracking) performance in these laboratory tests with that in outdoor atmospheres Author

N72-21904# Newcastle upon Tyne Univ (England) Dept of Metallurgy

STRESS CORROSION TEST METHODS THE EUROPEAN FEDERATION OF CORROSION CONTRIBUTION

R N Parkins *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 7 p (See N72-21900 12 32)

Avail NTIS HC $6.00/MF $0.95

A precis is given of the major points on stress corrosion test methods as compiled by the European Federation of Corrosion Working Party. The data points to some of the

problems associated with the various methods of testing, such as the extensive use of time to failure as a parameter that measures susceptibility and the apparently poor reproducibility of threshold stress intensity values for stress corrosion cracking. On the environmental side of testing, the dangers in the use of standard solutions are indicated and the necessity, in simulating service failures, of precisely reproducing the composition of the environment and the relevant electrode potential are shown
Author

N72-21905*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif
SOME IMPORTANT CONSIDERATIONS IN THE DEVELOPMENT OF STRESS CORROSION CRACKING TEST METHODS
R P Wei (Lehigh Univ), S R Novak (US Steel Corp, Monroeville, Pa), and D P Williams *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 10 p refs (See N72-21900 12-32)
(Contract N00014-68-A-0514)
(NASA-TM-X-68303) Avail NTIS CSCL 14B

The need for recognizing certain potentially serious problems in the development of standard test methods for stress corrosion cracking studies is discussed. The importance of recognizing and satisfying the basic assumptions of the linear elastic fracture mechanics analysis in experimentation is re-emphasized. The effects of nonsteady-state crack growth, including incubation, must be taken into account in determining the crack growth kinetics. These effects and the influences of steady-state crack growth kinetics, as well as a host of geometrical material and environmental variables, must be considered in arriving at suitable criteria for KISCC (apparent threshold for stress corrosion cracking) determinations
Author

N72-21906# British Steel Corp, Sheffield (England)
CURRENT PROGRESS IN THE COLLABORATIVE TESTING PROGRAMME OF THE STRESS CORROSION CRACKING (FRACTURE MECHANICS) WORKING GROUP
A H Priest and P McIntyre *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 17 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00 MF $0.95

A preliminary analysis is presented of the initial results of the Collaborative Testing Program of the Stress Corrosion Cracking (Fracture Mechanics) Working Group of the BSC Corporate Laboratories. In this analysis the results are interpreted in terms of the influences of specimen geometry, maximum fatigue precracking stress intensity, test temperature and laboratory error. It is concluded that the only significant errors can be attributed to differences in the calibration and accuracy of testing equipment between the participating laboratories and to failure to adhere to the recommended testing procedure which is found to be satisfactory for the material and environment which were used
Author

N72-21907# Leeds Univ (England) Dept of Metallurgy
THE SCIENCE COMMITTEE CONFERENCE ON THE THEORY OF STRESS CORROSION CRACKING OF ALLOYS
J C Scully *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 6 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00 MF $0.95

The general aspects of stress corrosion cracking as well as individual alloy systems are considered. Of particular interest to testing methods were (1) repassivation and (2) measurements of crack velocity. These are discussed and their relevance to testing methods is emphasized. Comparison between different alloys or of different heat treatments of an alloy can only be made if the relationship between mechanical, metallurgical and electrochemical variables on crack propagation kinetics is fully determined
Author

N72-21908# Tyco Labs, Inc, Waltham, Mass Materials Science Dept
MEASURING THE DEGREE OF CONJOINT ACTION BETWEEN STRESS AND CORROSION IN STRESS CORROSION
Franklin H Cocks *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 7 p (See N72-21900 12-32)
Avail NTIS HC $6.00/MF $0.95

A stress corrosion testing method which allows a quantitative separation between the effects of stress and those of corrosion in causing stress corrosion damage is described. This test involves the measurement of the reduction in subsequent stress corrosion life which is brought about by initially exposing the sample to the corrosive environment without any stress being applied (precorrosion). If a given alloy is susceptible only to the combination of stress and corrosion (true stress corrosion), then such a preexposure would not be expected to greatly reduce its subsequent stress corrosion lifetime. If, however, a corrosion process that is not accelerated by stress is required to initiate the failure process, then such preexposure without applied stress may be found to be almost as damaging as an equal amount of exposure carried out under stress. A stress corrosion index (SCI) is defined which quantitatively measures these effects. Data obtained by this method are presented for a high strength aluminum alloy (7075) tested in buffered Nacl solution. For specimens of this alloy having a machined surface finish, 80% of the time required to produce failure in normal stress corrosion tests is found to be due to a process which is not accelerated by applied stress. An explanation for this behavior is offered in terms of the existence of a highly deformed surface layer within which any well defined grain boundaries have been destroyed. This surface layer must be penetrated by pitting before a true stress corrosion process can begin
Author

N72-21909# Bell Aerospace Co, Buffalo, N Y
THE pH AND POTENTIAL MEASUREMENTS DURING STRESS CORROSION OF ALUMINUM ALLOYS
J A Davis *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 15 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00 MF $0.95

A technique was described for using small tip diameter microelectrodes to study the stress corrosion behavior of various aluminum alloys exposed to chloride environments. Several general observations concerning the stress corrosion behavior of aluminum alloys were made (1) propagation of a stress corrosion crack is always accompanied by a decrease in pH near the crack tip, (2) increasing the stress intensity to above KISCC (threshold stress intensity for stress corrosion cracking) results in a rapid active shift in corrosion potential, and (3) as cracks progress, the corrosion potential slowly drifts in the active direction. A general mechanism for stress corrosion based on these observations is that crack propagation occurs by active path dissolution with a minimum applied stress required to rupture the passive film and initiate crack propagation
Author

N72-21910# Welding Inst, Cambridge (England)
STRESS CORROSION TESTING OF WELDED JOINTS
T G Gooch *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 7 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00 MF $0.95

The techniques used for assessing the stress corrosion behavior of welded joints are outlined. Special attention was given to quantitative assessment of the suceptibility of weldments in the range of transformable steels, the cause of failure and the effects of material composition and microstructure. Several [illegible] of the results are given
Author

N72-21911# Department of Energy, Mines and Resources Ottawa (Ontario) Corrosion Section
SCREENING TESTS OF SUSCEPTIBILITY TO STRESS CORROSION CRACKING
G J Biefer and J G Garrison *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 9 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00/MF $0.95

For five high strength alloys susceptibilities to the propagation of stress corrosion cracking (SCC) were assessed. Using 3.5% NaCl solution as the medium, both parent and weld metals were investigated. Specimens were studied under freely corroding conditions, and also cathodically protected at the potentials given by cadmium and by zinc sacrificial anodes. The cantilever test was used, the test specimens, cut from 1/2- and 3/4-in. plates, were bars notched on both the sides and the top. Prior to tests a pre-crack was always produced at the base of the top notch by fatiguing in air. The equipment was designed so that specimens, loaded as cantilevers, were broken by means of a steadily rising load. This was applied by dripping water at a constant rate into a container suspended from the end of the cantilever beam. Results were reported in terms of the nominal stress intensities K* at fracture. While, strictly speaking, only of qualitative significance, reproducibility of the K* values was good and the effects of metallurgical and environmental factors could be readily estimated Author

N72-21912# Naval Air Development Center, Johnsville, Pa
STRESS CORROSION TESTING OF TITANIUM ALLOYS
S J Ketcham, C E Neu, and S Goldberg (Naval Air Sys Command) *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 8 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00/MF $0.95

Results are presented of two studies (1) effect of grain flow orientation on stress corrosion susceptibility of two titanium alloys and (2) stress corrosion tests of titanium electron beam weldments. Emphasis is on test specimens used and on some properties of titanium alloys which have to be considered when conducting stress corrosion tests Author

N72-21913# British Steel Corp Sheffield (England)
FACTORS INFLUENCING THRESHOLD STRESS INTENSITY VALUES AND CRACK PROPAGATION RATES DURING STRESS CORROSION CRACKING TESTS OF HIGH STRENGTH STEELS
A H Priest and P McIntyre *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 12 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00/MF $0.95

Threshold stress intensity values for stress corrosion cracking (KISCC) of a number of steels was shown to be related to the formation of a continuous stretch zone at the fatigue crack tip. Both KISCC and crack propagation rate (KIC) values are influenced by the yield strength and inclusion density of the steel. The relative values of KISCC determined by arrest and initiation methods and stress corrosion crack growth rates are influenced by the effectiveness of stress corrosion cracks as stress concentrators since intergranular cracks become progressively more blunt as they propagate while the reverse can be true of transgranular cracks. Observed stress corrosion crack propagation rates are also influenced by the failure to attain equilibrium in specimens of conventional length and by the presence of crack curvature and crack branching where these occur Author

N72-21914# Westinghouse Research Labs, Pittsburgh, Pa Mechanics Dept
AN APPARATUS FOR STRESS CORROSION TESTING WITH LARGE PRECRACKED WOL SPECIMENS
L J Ceschini and W G Clark Jr IN AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 9 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00/MF $0.95

A laboratory test unit designed for KISCC (value of plane-strain stress-intensity factor below which an existing crack will not grow due to stress corrosion) and stress corrosion crack growth rate testing with large precracked WOL (wedge-opening loading) specimens is described. The apparatus involves the use of a unique hydraulic loading arrangement which provides a convenient means of generating the relatively high loads required for stress corrosion testing with large WOL specimens. Additional features of the test unit include the ability to continuously monitor crack growth during the test and also the ability to test in an enclosed environment at various temperatures and pressures Author

N72-21915# Frankford Arsenal, Philadelphia, Pa
TENSILE LIGAMENT INSTABILITY AND THE GROWTH OF STRESS CORROSION CRACKS IN A HOMOGENEOUS Zn-Mg-Cu ALUMINUM ALLOY
Joseph H Mulherin *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 7 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00/MF $0.95

The application of the Krafft tensile ligament model to the stress corrosion phenomenon of a homogeneous Zn-Mg-Cu aluminum alloy is discussed. The variant in the series was the degree of homogeneity of the microstructure. According to the model, the largest variation in the susceptibility to stress corrosion crack propagation was attributable to an increase in the rate of surface chemical attack around the circumference of the ligaments Author

N72-21916# North American Rockwell Corp, Thousand Oaks, Calif Science Center
AN ULTRA-HIGH VACUUM SYSTEM FOR DETERMINING THE EFFECTS OF GASEOUS ENVIRONMENTS ON FATIGUE AND FRACTURE PROPERTIES OF METALS
H L Marcus and P J Stocker *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 8 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00/MF $0.95

A high vacuum, 10 to the minus 10th power torr, all-metal system is described in which crack growth behavior of metals under static and dynamic loading can be studied. Provisions are made to introduce clean gases to the system, such as hydrogen and oxygen to study their effects on the crack growth phenomena. Crack growth results are presented for Ni 200 exposed to low pressures of hydrogen gas in the 10 to the minus 8th power to 150 torr pressure range Author

N72-21917# Ohio State Univ, Columbus Dept of Metallurgical Engineering
ACOUSTIC EMISSIONS AND SLOW CRACK GROWTH IN HIGH STRENGTH STEEL
R W Staehle and G E Kerns *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 12 p refs (See N72-21900 12-32)
Avail NTIS HC $6.00/MF $0.95

Acoustic emission techniques were used to study stress corrosion cracking in high strength material. Pre-fatigue cracked single cantilever specimens were loaded and exposed to gaseous and aqueous environments. Acoustic emission signal shape and total resonance counts were recorded for specimens of different strength levels tested in different environments. Also, the phenomenon of wave reflection was reduced in order to examine the frequency content and energy of the emission. The results show that a higher strength level produces more acoustic activity regardless of environment. Also, the generated stress wave is of a high frequency and low energy nature Author

N72-21918# Fiat S p A , Turin (Italy) Lab Auto Avio
A CONTRIBUTION TO STRESS CORROSION TESTING OF ALUMINUM ALLOYS
Giovanni Bollani *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 13 p refs (See N72-21900 12-32)
Avail NTIS HC $6 00/MF $0 95

The results of an extensive investigation for the improvement of the stress corrosion testing methods on high strength Al alloys are briefly outlined For the evaluation of the crack initiation period under different stress conditions, two smooth specimens of original design are recommended For the measure of the crack propagation rate, the D C B (Double Cantilever beam) pre-cracked specimen was found effective Author

N72-21919# Naval Ship Research and Development Center, Annapolis, Md Corrosion Branch
INFLUENCE OF TEST METHOD ON STRESS CORROSION BEHAVIOR OF ALUMINUM ALLOYS IN SEA WATER
George J Danek *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 11 p refs (See N72-21900 12-32)
Avail NTIS HC $6 00/MF $0 95

Highlights are presented of recent investigations on sea water stress corrosion behavior of high strength aluminum alloys Rolled 7000-series plate was used to show a significant influence of specimen orientation on sea water stress corrosion response The results suggested that tests in the short transverse direction are essential in ascertaining stress corrosion behavior of high strength aluminum alloys in either smooth or precracked specimens Based on these results a number of high strength hand forgings, representing the 2000-, 6000-, and 7000-series were tested as bent beam and precracked cantilever specimens taken in the short transverse direction Inconsistencies are observed when the sea water stress corrosion results from precracked cantilever specimens are compared to those from smooth specimens The results indicate that each of the two techniques provides important information, and both methods should be used in assessing the sea water stress corrosion behavior of high strength aluminum alloys Author

N72-21920# Aluminum Co of America, Pittsburgh Pa Chemical Metallurgy Div
DISCUSSION OF PAPER, INFLUENCE OF TEST METHOD ON STRESS CORROSION BEHAVIOR OF ALUMINUM ALLOYS IN SEAWATER BY GEORGE J DANEK
Donald O Sprowls and J G Kaufman *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 7 p refs (See N72-21900 12 32)
Avail NTIS HC $6 00 MF $0 95

It is shown that the method of testing with precracked specimens may be affected as much or more, than traditional smooth specimen methods On the basis of estimated threshold stress intensities obtained with precracked cantilever beam specimens rankings of alloys are reported that are unrealistic compared to service experience and estimated threshold stresses obtained from tests of smooth beam specimens Tests of the same alloys with bolt loaded precracked double cantilver beam specimens ranked the alloys in good agreement with rankings obtained from tests of smooth tensile specimens Author

N72-21921# Societe Nationale Industrielle Aerospatiale Paris (France)
PARTICIPATION OF THE STUDY OF CORROSION UNDER TENSION OF CERTAIN HIGH RESISTANCE ALUMINUM ALLOYS [PARTICIPATION A L'ETUDE DE LA CORROSION SOUS TENSION DE CERTAINS ALLIAGES D'ALUMINIUM A HAUTE RESISTANCE]
Robert Doste *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 15 p In FRENCH (See N72-21900 12 32)
Avail NTIS HC $6 00 MF $0 95

Experiments were conducted on corrosion under tension of two of the principal aluminum alloys used in the French aircraft industry A-U2GN and A-U4SG A number of systematic tests were made using classical tests methods under conditions of flexure, with a constant imposed load Processes occurring during corrosion and stress corrosion are most often electrochemical reactions and certain study techniques are described for electrochemical methods, in order to establish a correlation between observed phenomena and the particular microstructures of the alloys In the case of the a-U2GN alloy, an explanation is advanced based on sensitivity to intercrystalline corrosion and the role of constraint, as well the desensitizing which occurs after proper heat treatment Heat treatment of the alloy A-U4SG diminishes the susceptibility of the material to intercrystalline corrosion, while sensitivity to stress corrosion remains significant The influence of aeration on the solution appears to be of major importance Transl by K P D

N72-21922# Industrieanlagen-Betriebsgesellschaft m b H , Ottobrunn (West Germany)
RESULTS OF COMPARATIVE STRESS CORROSION TESTS ON AlZnMgCu-ALLOYS USING DIFFERENT TYPES OF SPECIMENS
Werner Lehmann *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 15 p (See N72-21900 12-32)
Avail NTIS HC $6 00 MF $0 95

In order to evaluate and to compare the stress corrosion behavior of more complicated structural parts for example die forgings from the two different alloys 7079-T6 and AZ 74 61, various types of specimens were taken from critical locations on the forging These locations are the area around the jack point hole, the main parting plane and the area of the first two rows of bolt holes C rings, precracked DCB specimens, and smooth tension specimens were examined, using a standard 3 5 % NaCl alternate immersion test The test specimens were periodically inspected in order to find out the time to failure (tension specimens), the time to the first crack or to complete fracture (C-rings), and the crack length as a function of time as well as the threshold stress value (DCB specimens) The results show that forgings from the alloy AZ 74 61 are superior to those of 7079-T6 Author

N72-21923# Carpenter Technology Corp , Reading, Pa
STRESS CORROSION CRACKING OF MARTENSITIC PRECIPITATION HARDENING STAINLESS STEELS
Michael Henthorne *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 8 p refs (See N72-21900 12-32)
Avail NTIS HC $6 00 MF $0 95

Stress corrosion cracking tests on two precipitation-hardened stainless steels, Custom 455 and Custom 450 were used to study the effects of heat treatment, product size, type of test specimen, and test environment Smooth specimens (tensile, bent beam and U-bend) and precracked cantilever beams were tested in sodium chloride solution, salt spray and a natural marine atmosphere The cracking resistance of Custom 455 improves significantly as the aging temperature is increased i e as the yield strength decreases and the toughness increases Specimens cut from large product sizes (e g billet) have lower fracture toughness than smaller sizes (e g bar) The differences between stress corrosion and cracking in galvanic corrosion situations are discussed Author

N72-21924# Societe Nouvelle des Acieries de Pompey (France)
INVESTIGATION OF AN ACCELERATED STRESS CORROSION CRACKING METHOD
M Hugo, J Bellot, and E Herzog *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 11 p refs (See N72 21900 12 32)
Avail NTIS HC $6 00 MF $0 95

An accelerated slow strain rate tensile method of testing is suggested which may be useful for inspection purposes Slow straining in nitrate, NaOH and acid environments are described Author

N72-21925# United States Steel Corp., Monroeville, Pa Applied Research Lab

MICROSCOPIC IDENTIFICATION OF STRESS CORROSION CRACKING IN STEELS WITH HIGH YIELD STRENGTH

E H Phelps *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 14 p refs (See N72-21900 12-32)

Avail NTIS HC $6.00/MF $0.95

The microscopic features of stress corrosion cracking in steels with high yield strength are reviewed with the objective of establishing specific characteristics by which stress corrosion can be identified. Photomicrographs of stress corrosion cracking obtained under known exposure conditions on specimens of alloy steels, of precipitation hardenable stainless steels, and of maraging steels are presented and discussed. The most consistent feature of stess corrosion cracking in these steels is that it usually is initiated at multiple sites on the steel surface. Cracking may be intergranular or transgranular, depending on the alloy system and the environment. Branching occurs in some instances but is not a consistent characteristic of stress corrosion cracking in steels with high yield strength. Author

N72-21926*# National Aeronautics and Space Administration Langley Research Center, Langley Station, Va

HOT SALT STRESS CORROSION CRACKING OF TITANIUM ALLOYS: OVERVIEW AND IMPACT ON SPACE SHUTTLE APPLICATION

W Barry Lisagor and James E Gardner *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 10 p refs (See N72-21900 12-32)

(NASA-TM-X-68304) Avail NTIS CSCL 11F

The test program described was conducted to determine if onset of hot salt stress corrosion cracking would occur in the cumulative exposure of time, temperature, and stress currently considered for titanium heat shields in the shuttle mission. In addition, efforts were made to assess the effects of cyclic exposure on cracking, to compare the resistance to cracking of the two proposed prime candidate alloys (Ti-6A1-4V and Ti-6A1-2Sn-4Zr-2Mo) and to determine the effect of Mach 3 airflow on cracking behavior. The results indicate that cracking will occur on salt coated specimens continuously exposed in laboratory ovens for 100 hours at temperatures and stresses proposed for shuttle TPS application. However, both cyclic exposure and exposure in a Mach 3 airstream tend to decrease the damage observed. The Ti-6Al-4V alloy exhibited a higher threshold stress than the Ti-6Al-2Sn-4Zr-2Mo alloy but suffered more apparent damage once onset of cracking occurred. Author

N72-21927# Battelle Memorial Inst., Columbus, Ohio Corrosion Research Div

THE USE OF SLOW STRAIN RATE EXPERIMENTS IN EVALUATING RESISTANCE TO ENVIRONMENTAL CRACKING

James E Reinoehl and Walter K Boyd *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 5 p refs (See N72-21900 12-32)

Avail NTIS HC $6.00 MF $0.95

An experimental procedure is described for evaluating resistance to stress corrosion cracking. Relative degrees of susceptibility to environmental cracking and embrittlement can be determined as a function of mechanical ductility (parameters reduction in area, elongation, etc.) or as a function of electrochemical polarization parameters (electrode potential, pH, solution composition, etc.) by pulling cylindrical tensile specimens at a slow strain rate while they are subjected to controlled electrochemical and environmental conditions (electrode potential, solution composition, temperature, etc.). Author

N72-21928# Lockheed-California Co., Burbank Materials Research Lab

EXPERIMENTAL TECHNIQUES USED TO STUDY STRESS CORROSION MECHANISMS IN AIRCRAFT STRUCTURAL ALLOYS

G M Hoch, W F Krupp, and K E Weber *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 10 p refs (See N72-21900 12-32)

Avail NTIS HC $6.00/MF $0.95

Various techniques for the study of crack morphology, contaminant identification, and electrochemistry are considered. These include the use of time lapse photography, transmission and scanning electron microscopy, introduction of radioactive elements into the corrosive media under study, and pH and oxidation-reduction indicators. K.P.D.

N72-21929# Ecole des Mines, Paris (France)

FRACTURE INITIATION AND STRESS CORROSION CRACKING OF WELDED JOINTS OF ALPHA TYPE TITANIUM ALLOYS

C Chassion and P R Krahe *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 6 p refs (See N72-21900 12-32)

Avail NTIS HC $6.00/MF $0.95

The almost instantaneous failure of some welded joints of certain Ti-Al-Sn alpha type alloys when in contact with carbon tetrachloride vapor, was studied and related to the slight surface contamination developed during argon arc welding. Analysis of the contaminated layers with the Castaing-Slodzian ion probe showed that a substantial amount of oxygen penetration had occurred during the welding operation. Testing showed that the susceptibility to stress corrosion was related to the extent of this penetration and microcracks were observed to form on the welded surfaces after loading, but before contact with the corrosion medium. As oxygen in solid solution in titanium reduces its ductility, these mechanical cracks propagate under the action of a constant load deeper into the more contaminated samples. Author

N72-21930# Istituto di Ricerche Breda S.p.A., Milan (Italy)

PRELIMINARY REPORT ON THE RESEARCH ON THE INFLUENCE OF THERMOMECHANICAL TREATMENTS ON STRESS CORROSION CRACKING BEHAVIOUR OF AISI 4340 STEEL

R DeSantis, L Matteoli, and T Songa *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 5 p refs (See N72-21900 12-32)

Avail NTIS HC $6.00/MF $0.95

Two grades of 4340 AISI steel were selected air-melted and electroslag remelted. Experimental results are presented which were obtained by testing the hardness of two specimens of both steel grades subjected to thermomechanical treatments. The hardness recovery of the steels tempered at 200 C is very small, if not absent, and sometimes it takes place after a very long tempering time. This phenomenon is very marked for the 300 C tempered steels; in this case long tempering time causes a second decrease of the hardness in a way typical for aging phenomena. No clear relation seems to exist between the metallurgical grade of the material and the behavior upon deformation and second tempering. Moreover there were significant differences in the results obtained on different specimens of the same material. Author

N72-21931# Istituto Sperimentale dei Metalli Leggeri, Novara (Italy) Metallurgy Dept

PRELIMINARY RESULTS OF MECHANICAL AND STRESS CORROSION TESTS ON PLATES OF 7075 ALLOY PRODUCED BY A NEW PROCESSING TECHNIQUE

E DiRusso, M Conserva, and M Buratti *In* AGARD Specialists Meeting on Stress Corrosion Testing Methods Jan 1972 6 p (See N72-21900 12-32)

Avail NTIS HC $6.00/MF $0.95

The primary and secondary properties of hot rolled plates of 7075 alloy are briefly described. The materials show a reduction of the transverse effect compared to conventionally produced plates. Improved characteristics of ductility, fracture toughness and stress corrosion resistance were attained in the short transverse direction along with strength levels equal to or higher than those of similar materials produced in the traditional way. Author

N72-22918# Advisory Group for Aerospace Research and Development, Paris (France).
THE ACCUMULATION OF FATIGUE DAMAGE IN AIRCRAFT MATERIALS AND STRUCTURES
J Schijve (Natl. Aerospace Lab., Amsterdam) Jan. 1972 125 p refs
(AGARD-AG-157; AGARDograph-157) Avail NTIS

The available literature in the field of fatigue damage accumulation is surveyed and analyzed. Physical aspects of fatigue damage accumulation are discussed, including interaction and sequence effects. Empirical trends observed in variable-amplitude tests are summarized including the effects of a high preload, periodical high loads, ground-to-air cycles and the variables pertaining to program loading, random loading and flight-simulation loading. This also includes results from full-scale fatigue test series. Various theories on fatigue damage accumulation are recapitulated. The significance of these theories for explaining empirical trends as well as for estimating fatigue properties as a design problem is evaluated. For the latter purpose reference is made to the merits of employing experience from previous designs. Fatigue testing procedures are discussed in relation to various testing purposes. Emphasis is on flight-simulation tests. Finally several recommendations for further work are made. Author

N72-24934# Advisory Group for Aerospace Research and Development, Paris (France)
NONDESTRUCTIVE TESTING AND INSPECTION APPLIED TO COMPOSITE MATERIALS AND STRUCTURES
Feb 1972 34 p refs Presented at 32d AGARD Structures and Mater. Panel Meeting, London, 31 Mar 1971
(AGARD-R-590) Avail NTIS HC $3.75

Papers on nondestructive testing applied to specimens and structural parts made of composite materials are presented. Various methods for failure inspection in carbon fiber composites and the possibilities and limitations of nondestructive inspection for quality control of airframes made of boron composites are discussed. For individual titles, see N72-24935 through N72-24936

N72-24935# Cranfield Inst. of Technology (England)
NONDESTRUCTIVE TESTING OF CARBON FIBRE REINFORCED POLYMERS
C N Owston *In* AGARD Nondestructive Testing and Inspection Applied to Composite Mater. and Structures Feb 1972 p 1-21 Sponsored by Min. of Aviation Supply (See N72-24934 15-32)
Avail NTIS HC $3.75

Ultrasonic, radiographic, eddy current, and acoustic emission techniques are described, and possible failure mechanisms especially in fatigue, are discussed. It is concluded that nondestructive testing of carbon fiber composites is feasible. Care must be exercised in realizing that composites are not metals, and the interpretation of the indicators may be different. There are few case histories of failure with composites and predictions of the importance of defects is less certain than for metals. In general, variations in the fibrous part of the composite are easy to locate and predictions of failure are easier to make. Techniques for looking at the matrix are not so good and there is less confidence in nondestructive testing where the performance of the component is markedly matrix dependent. Author

N72-24936# Air Force Materials Lab. Wright-Patterson AFB Ohio Advanced Composites Div
NONDESTRUCTIVE INSPECTION PRACTICES USED IN PRODUCTION OF COMPOSITE AIRFRAME STRUCTURES
E H Jaffe *In* AGARD Nondestructive Testing and Inspection Applied to Composite Mater. and Structures Feb. 1972 p 23-31 (See N72-24934 15-32)
Avail NTIS HC $3.75

The possibilities and limitations of nondestructive inspection (NDI) applied to the quality control of a primary structural part made of boron composite are described. The NDI is discussed using typical first generation high modulus composite aircraft empennage structures as examples of current practices in airframe production. The following subjects are discussed: (1) the most frequently occurring defects in manufacture of composite structures, (2) major NDI techniques currently available, and their limitations, (3) some newer techniques, and how they will fill the gap, and (4) problems of acceptance/rejection criteria, and how these decisions may be quantified. Author

N72-28902# Rolls-Royce, Ltd., Watford (England) Small Engine Div
THE INFLUENCE OF FRETTING ON FATIGUE. PART 3
W J Harris Paris AGARD Jun 1972 25 p
(AGARD-AR-45) Avail NTIS HC $3.[illegible]

The effects of fretting on the fatigue properties of various materials are discussed. The development and evaluation of anti-fret media on titanium and aluminum alloys is described. The laboratory equipment used to conduct the experiments is illustrated. Tables and graphs are included to portray the results of the experiments. P N F

N72-29893# Advisory Group for Aerospace Research and Development, Paris (France)
ACOUSTIC FATIGUE DESIGN DATA, PART 1
A G R Thomson (Eng. Sci. Data Unit Ltd.) May 1972 58 p refs
(AGARD-AG-162-Pt-1; AGARDograph-162-Pt-1) Avail NTIS HC $5.00

The problem of acoustic fatigue life of a structure subjected to jet noise is introduced. A framework of a design procedure applicable especially to skin panels is described. A method of estimating the near field sound pressure levels due to high velocity jet noise is described including its limitations. Methods are described to predict the first two groups of natural frequencies of flat and singly curved skin-stringer structures with four different end conditions. The parameters considered are (1) stringer torsional stiffness, (2) aspect ratio of a typical section, and (3) the number of half-waves across the frame pitch. A method of estimating the root mean square in rectangular skin panels subject to random acoustic loading is presented. Author

N72-33915# Advisory Group for Aerospace Research and Development, Paris (France)
A COMPARISON OF METHODS USED IN FLUTTER RESEARCH
H G Kuessner (DFVLR, Goettingen, West Germany) Aug 1972 141 p refs
(AGARD-R-592) Avail NTIS HC $9.25 CSCL 01C

The eigenfrequencies, modes and generalized masses of the F104G aircraft have been calculated from the drawings by the finite element method. The idealization of the structure by different types of elements and the formation of the corresponding mass matrix by adding lumped masses are described. The structure is divided into isolated substructures. By several condensation procedures the number of symmetric and antisymmetric unknowns has been reduced stepwise from 8250 + 7948 to 170 + 162. The rigid body modes have been eliminated by 3 + 3 supports and by a modified mass matrix. The results of the calculation of 24 modes are described and illustrated. Only 13 of them were comparable with corresponding measurements of two independent ground vibration tests. Whereas the eigenfrequencies agree within a few percent the mode shapes and the corresponding generalized masses show large differences and suggest the need for further improvements of the calculation method. Author

N73-14898# Advisory Group for Aerospace Research and Development, Paris (France)
ACOUSTIC FATIGUE DESIGN DATA, PART 2
A G R Thomson (Engineering Sci. Data Unit Ltd.) and R F Lambert (Engineering Sci. Data Unit Ltd.) Nov 1972 59 p refs
(AGARD-AG-162-Pt-2; AGARDOGRAPH-162-Pt-2) Avail NTIS HC $5.00

Data for use in aerodynamic structural design to reduce the effects of acoustic fatigue are presented The subjects discussed are (1) endurance of aluminum alloy structural elements subjected to acoustic loading (2) natural frequencies of flat or singly curved sandwich panels with cores of zero flexural stiffness and (3) stress response of flat or singly curved sandwich panels with cores of zero flexural stiffness subjected to random acoustic loading Author

N73-16896# Advisory Group for Aerospace Research and Development Paris (France)
SYMPOSIUM ON RANDOM LOAD FATIGUE
Oct 1972 237 p refs Symp held at 34th meeting of the AGARD Struct and Mater Panel, Lyngby, Denmark, 13 Apr 1972 sponsored by Struct and Mater Panel
(AGARD-CP-118) Avail NTIS HC $14.00

Physical aspects of fatigue damage accumulation and the significance of theories for the calculation of fatigue damage accumulation are reviewed Influence of test frequencies on crack propagation rates, measurements of residual stresses in notched specimens etc are reported For individual titles, see N73-16897 through N73-16904

N73-16897 Societe Nationale Industrielle Aerospatiale Paris (France)
A SHORT SURVEY ON POSSIBILITIES OF FATIGUE LIFE ASSESSMENT OF AIRCRAFT STRUCTURES BASED ON RANDOM OR PROGRAMMED FATIGUE TESTS
W Barrois *In* AGARD Symp on Random Load Fatigue Oct 1972 21 p refs (For availability see N73-16896 07-32)

After considering designers' needs and detailing the various physical parameters that are significant in the fatigue behavior of specimens and structures several types of fatigue tests are reviewed Prediction methods of structure fatigue life from fatigue tests of components assemblies and structures undergoing constant amplitude loadings are surveyed After considering fatigue tests under programmed loadings the case of random loadings is briefly discussed It is concluded that describing random loadings by their root mean squares is not sufficient to predict the fatigue lives of structures even when the shape of the load power spectrum is known except in cases of comparative prediction where the only change is the general intensity of the spectrum The possibility of test acceleration by increasing the general loading intensity is considered Author

N73-16898 Royal Aircraft Establishment Farnborough (England) Structures Dept
SOME EFFECTS OF CHANGE IN SPECTRUM SEVERITY AND SPECTRUM SHAPE ON FATIGUE BEHAVIOUR UNDER RANDOM LOADING
W T Kirkby *In* AGARD Symp on Random Load Fatigue Oct 1972 19 p refs (For availability see N73-16896 07-32)

The problem of reassessing the fatigue life of an aircraft structure is considered when it is found that the spectrum of loads experienced in service differs from the load spectrum applied in test Results obtained during fatigue tests on structural elements under random load spectra are used to illustrate some of the important considerations involved It is shown that the use of an improved method of life prediction will generally lead to improved accuracy in reassessing life Author

N73-16899 National Aerospace Lab Amsterdam (Netherlands)
THE ACCUMULATION OF FATIGUE DAMAGE IN AIRCRAFT MATERIALS AND STRUCTURES
J Schijve *In* AGARD Symp on Random Load Fatigue Oct 1972 120 p ref (For availability see N73-16896 07-32)

Physical aspects of fatigue damage accumulation are discussed including interaction and sequence effects Empirical trends observed in variable amplitude tests are summarized including the effects of a high preload periodical high loads ground to air cycles and the variables pertaining to program loading random loading and flight simulation loading This also includes results from full scale fatigue test series Various theories of fatigue damage accumulation are recapitulated The significance of these theories for explaining empirical trends as well as for estimating fatigue properties as a design problem is evaluated Author

N73-16900 National Aerospace Lab, Amsterdam (Netherlands)
EFFECTS OF TEST FREQUENCY ON FATIGUE CRACK PROPAGATION UNDER FLIGHT SIMULATION LOADING
J Schijve *In* AGARD Symp on Random Load Fatigue Oct 1972 17 p refs (For availability see N73-16896 07-32)

Fatigue crack propagation in 2024-T3 and 7075-T6 sheet material was studied at three test frequencies, viz 10, 1, and 0.1 cycles per second The flight simulation loading was based on a gust spectrum The design stress level was adopted as a second variable Differences between the crack propagation rates at the three test frequencies were small and unsystematic The propagation was much slower than predicted from constant amplitude test data Moreover, the macro-cracking behavior appeared to be different Author

N73-16901 Air Force Systems Command, Wright-Patterson AFB, Ohio
CORRELATION BETWEEN LABORATORY TESTS AND SERVICE EXPERIENCE
W B Miller and Holland B Lowndes *In* AGARD Symp on Random Load Fatigue Oct 1972 10 p refs (For availability see N73-16896 07-32)

Direct comparisons are made between full scale fatigue test failures and actual service failures for several military aircraft The correlations are discussed in relation to the basic fatigue test procedures and spectra used Some methods used to force correlation where apparent correlation is lacking are discussed The improvements in fatigue testing evolved over the past 25 years are summarized Author

N73-16902 Technical Univ of Denmark Lyngby Dept of Solid Mechanics
ON RESIDUAL STRESSES DURING RANDOM LOAD FATIGUE
Find Rotvel *In* AGARD Symp on Random Load Fatigue Oct 1972 14 p refs (For availability see N73-16896 07-32)

Data are presented from random fatigue tests on normalized carbon steel with 0.7% carbon In notched specimens a preload beyond the yield stress induced residual stresses around the notch The residual stresses were measured with an X-ray measuring technique at intervals during the fatigue loading Results from broadband and narrowband stochastic loading tests are compared with constant amplitude sinusoidal tests Author

N73-16903 Industrieanlagen Betriebsgesellschaft m b H Ottobrunn (West Germany)
THE FATIGUE LIFE UNDER THREE DIFFERENT LOAD SPECTRA - TESTS AND CALCULATIONS
Walter Schuetz *In* AGARD Symp on Random Load Fatigue Oct 1972 10 p refs (For availability see N73-16896 07-32)

One of the more important problems in the fatigue life prediction of military airplanes is caused by the difference between the load spectrum used in the full scale fatigue test and the load spectrum in service Complex flight by flight tests with two types of notched specimens and a bolted joint simulating a skin fitting joint were carried out under three different load spectra occurring in service of a German military airplane It is shown that Miner's rule can be used as a transfer function (relative Miner rule) to calculate the lives with high accuracy for the notched specimens and with less accuracy for the bolted specimens Author

N73-16904 Laboratorium fuer Betriebsfestigkeit Darmstadt (West Germany)
A RELATION BETWEEN MEASURED CENTER OF GRAVITY VERTICAL ACCELERATIONS AND THE LOADS AT THE T TAIL OF A MILITARY AIRPLANE
Otto Buxbaum *In* AGARD Symp on Random Load Fatigue Oct 1972 15 p refs (For availability see N73-16896 07-32)

An engineering solution is presented for correlating two different random loads time histories based on measurements

of C G vertical accelerations and loads at the tailplane of an aircraft The choice of instrumentation for a fleet airplane is described, and the measurements of operational loads are related to C G acceleration countings Author

N73-18916# Advisory Group for Aerospace Research and Development Paris (France)
AD HOC GROUP ON LOW-CYCLE HIGH TEMPERATURE FATIGUE
J M Drapier (Centre de Rech Met, Liege) Dec 1972 33 p refs
(AGARD-R-604) Avail NTIS HC $3 75

This report presents information on the activities in low cycle fatigue testing at high temperature (LCHTF) as received from 57 laboratories (industry and universities) in 9 NATO nations The information includes the interest and activity in LCHTF testing techniques and conditions used Author

N73-18931# Advisory Group for Aerospace Research and Development Paris (France)
SUMMARY AND EVALUATION OF SPECIALISTS MEETING ON STRESS CORROSION TESTING METHODS
Donald E Piper (Lockheed Missiles and Space Co, Inc, Palo Alto, Calif) Dec 1972 11 p refs
(AGARD-AR-52) Avail NTIS HC $3 00

A summary is presented of the two-day Specialists Meeting on Stress Corrosion Testing Methods held during the 33rd Meeting of the Structures and Materials Panel of the Advisory Group for Aerospace Research and Development (AGARD) in Brussels, Belgium on October 5 and 6, 1971 The program was prepared to promote free and candid discussion of (1) the utility and significance of stress-corrosion data to current engineering and design practices (2) the progress being made by NATO countries toward standardization of test techniques for stress-corrosion cracking and (3) those test methods which might be recommended as standard techniques in the immediate future Author

N73-28884# Advisory Group for Aerospace Research and Development, Paris (France)
TECHNICAL EVALUATION REPORT ON THE AGARD SYMPOSIUM ON RANDOM LOAD FATIGUE
Walter Schuetz (Industrieanlagen-Betriebsgesellschaft m b H) Jun 1973 13 p refs
(AGARD-AR-54) Avail NTIS HC $3 00

Brief summaries of the papers presented to the AGARD Symposium are presented Conclusions and recommendations are included Topics discussed include full scale fatigue testing, crack propagation under flight-by-flight loading, fatigue life prediction, measurement and estimation of fatigue loads, damage accumulation, and service experience F O S

N73-29905# Advisory Group for Aerospace Research and Development, Paris (France)
SYMPOSIUM ON ACOUSTIC FATIGUE
May 1973 273 p refs Partly in FRENCH mostly in ENGLISH Papers presented at 35th Meeting of the Structures and Mater Panel Toulouse 26-27 Sep 1972
(AGARD-CP-113) Avail NTIS HC $15 75

The proceedings of a conference on acoustic fatigue and methods for reducing the effects of acoustic fatigue are presented The subjects discussed include (1) dynamic loading of aircraft surfaces due to jet exhaust impingement, (2) response of structures to aerodynamic loads (3) design data for acoustic fatigue (4) damping and composite structures (5) sonic fatigue of bonded sandwich structures and (6) assessment of test techniques for determining extent of acoustic fatigue For individual titles see N73-29906 through N73-29923

N73-29906 Societe Nationale Industrielle Aerospatiale Toulouse (France) Bureau d Etudes
KEYNOTE ADDRESS [ALLOCUTION D'OUVERTURE]
Rene Loubet *In* AGARD Symp on Acoustic Fatigue May 1973 2 p in FRENCH (For availability see N73-29905 20 32)

The complexity of problems raised before the conference on acoustic fatigue are discussed Data cover constructive solutions, methods of prevention and control, and cooperation of various Nations in providing test procedures for the problems Transl by E H W

N73-29907 Dornier-Werke G m b H Friedrichshafen (West Germany)
INFLUENCE OF THE GROUND ON THE NEAR FIELD NOISE LEVELS OF JET-SUPPORTED V STOL AIRCRAFT
Rudolf Scholten *In* AGARD Symp on Acoustic Fatigue May 1973 12 p refs (For availability see N73-29905 20 32)

A method for calculating the near field noise level of a free jet (no ground effect) by means of a modified Lighthill theory using measured reference sound fields is explained The shortcomings of the reference fields presently used as well as a means to eliminate them, are shown In addition, determining frequency spectra in the near sound field by means of a modified Strouhal number is described The validity of the modified Lighthill theory is proven by means of two different engine jets Wall jet sound fields (sound fields of an engine jet directed vertically towards the ground) and the influence of the essential parameters affecting the sound field are discussed Increased noise levels due to grouned effect are examined using V STOL aircraft operation as an example Author

N73-29908* National Aeronautics and Space Administration Langley Research Center Langley Station Va
DYNAMIC LOADING OF AIRCRAFT SURFACES DUE TO JET EXHAUST IMPINGEMENT
D L Lansing J A Drischler, T J Brown, and J S Mixson *In* AGARD Symp on Acoustic Fatigue May 1973 9 p refs (For availability see N73-29905 20 32)
CSCL 01C

High lift wing concepts being considered for application to commercial STOL transports are discussed The flow patterns which produce dynamic loads on these wings are indicated Measurements of surface pressure and acceleration on a one half scale model of an externally blown double slotted flap are reported Root mean square values power spectra, and scaling parameters are shown Author

N73-29909 National Aeronautical Establishment Ottawa (Ontario) Structures and Materials Lab
SURFACE PRESSURE FLUCTUATIONS FROM JET IMPINGEMENT ON AN INCLINED FLAT PLATE
R Westley J H Woolley and P Brosseau *In* AGARD Symp on Acoustic Fatigue May 1973 18 p refs (For availability see N73-29905 20 32)

The influence of jet impingement pressure fluctuations on the structural design of short takeoff aircraft that use externally blown flaps is discussed An experiment is described in which the surface pressure fluctuations on a flat plate were measured when an impinging cold air jet was blown at the plate with various speeds inclination angles and separation distances The measured surface sound pressure levels and their spectra are reported Author

N73-29910* National Aeronautics and Space Administration Ames Research Center Moffett Field Calif
PRESSURE FLUCTUATION INPUTS AND RESPONSE OF PANELS UNDERLYING ATTACHED AND SEPARATED SUPERSONIC TURBULENT BOUNDARY LAYERS
Charles F Coe and Wei J Chyu *In* AGARD Symp on Acoustic Fatigue May 1973 20 p refs (For availability see N73-29905 20 32)
CSCL 20D

Results of an investigation of surface pressure fluctuations and response of panels underlying attached and separated turbulent boundary layers and shock waves are summarized Extensive tests of a large assortment of axisymmetric and two dimensional models have been conducted at transonic and supersonic Mach numbers to 3 6 to study the pressure fields Assorted fixed edge flat panels have been tested at Mach numbers from 1 6 to 3 6 in attached and completely separated flow fields

and also in mixed flow with a step induced shock wave oscillating on the panels The surface pressure fluctuations are described in terms of broadband rms spectral density and spatial correlation information The effectiveness of parameters for scaling the pressure fluctuations is also illustrated Measurements of the amplitude and strain response of the panels are compared with response computations by the normal method of analysis
Author

N73-29911 National Research Council of Canada Ottawa (Ontario)
ACCURATE FINITE ELEMENT MODELLING OF FLAT AND CURVED STIFFENED PANELS
G M Lindberg In AGARD Symp on Acoustic Fatigue May 1973 21 p refs (For availability see N73-29905 20 32)
The dynamics of stiffened [illegible] is were analyzed using three different stiffener models The more exact, complete beam finite element method was used in preference to the T-beam approach A rectangular cylindrical shell finite element has been derived and was used to study the dynamic of singly curved stiffened panels The major effect of the curvature is to increase the lowest frequencies and to broaden the banded nature of the results Higher frequencies are little affected by the changes in curvature
Author

N73-29912 British Aircraft Corp (Operating) Ltd Bristol (England) Structural Acoustics Group
RESPONSE AND FATIGUE CHARACTERISTICS OF LIGHT ALLOY MACHINED PLANK STRUCTURES
D C G Eaton In AGARD Symp on Acoustic Fatigue May 1973 17 p refs (For availability see N73-29905 20 32)
The response and fatigue characteristics of light alloy integrally machined planks are discussed The vibration characteristics are compared with those of equivalent fabricated conventional structures The characteristics are reviewed with emphasis on the related acoustic fatigue implications Methods of predicting dynamic stresses are considered and comparisons are made with practical results A research program for obtaining information to be used in preparing design guides is discussed Problems associated with noise induced crack propagation in machined plank structures are reported
Author

N73-29913 Societe Nationale Industrielle Aerospatiale Toulouse (France) Bureau d'Etudes
EXPERIMENTAL RESEARCH ON THE RESPONSE OF AIRCRAFT STRUCTURES TO ACOUSTIC FATIGUE [RECHERCHE EXPERIMENTALE DE LA TENUE DES STRUCTURES D'AVION A LA FATIGUE ACOUSTIQUE]
Jean Gay In AGARD Symp on Acoustic Fatigue May 1973 9 p In FRENCH (For availability see N73-29905 20-32)
Data are presented on conditions known to cause acoustic fatigue and test conditions necessary for treating or correcting the problem Data cover source of excitation, flight conditions and effects of aircraft critical zones on the problem Several test procedures were examined
Transl by E H W

N73-29914 Engineering Sciences Data Unit London (England)
DESIGN DATA FOR ACOUSTIC FATIGUE
A G R Thomson and R F Lambert In AGARD Symp on Acoustic Fatigue May 1973 16 p refs (For availability see N73-29905 20 32)
The development and preparation of data sheets for acoustic fatigue analysis and data recording are reported The data are classified according to the following (1) loading actions (2) natural frequencies (3) stress response of components under load and (4) fatigue life estimation Mathematical models for flat plate frequencies the effect of finite core shear stiffness and the influence of core orthotropy are presented
Author

N73-29915 Southampton Univ (England) Inst of Sound and Vibration Research
ESTIMATES OF THE RESPONSE OF BOX TYPE STRUCTURES TO ACOUSTIC LOADING
Brian L Clarkson In AGARD Symp on Acoustic Fatigue May 1973 16 p refs (For availability see N73-29905 20 32)
A multicell box structure representing typical aircraft construction was tested in a high intensity noise facility The vibration response of the internal ribs was studied The test specimen was designed in such a way the ribs could be changed to produce variants in a typical tailplane design A semi empirical method for analyzing the response is developed and compared with the experimental results
Author

N73-29916 Lockheed California Co Burbank
CORRELATION OF SONIC FATIGUE FAILURES IN LARGE FAN ENGINE DUCTS WITH SIMPLIFIED THEORY
Jaak Soovere In AGARD Symp on Acoustic Fatigue May 1973 14 p refs (For availability see N73-29905 20 32)
The nature of the large fan jet engine intake duct noise and its effect on the duct structure are described A simple semi-empirical method is developed to predict the stresses in intake duct structure induced by fan noise The predicted stresses at the failure location show good correlation with random fatigue data for bending across the rivet line
Author

N73-29917 British Aircraft Corp Weybridge (England) Commercial Aircraft Div
EXPERIMENTALLY DETERMINED DAMPING FACTORS
J A Hay In AGARD Symp on Acoustic Fatigue May 1973 15 p refs (For availability see N73-29905 20 32)
The effect of damping on the response of a structure to acoustic excitation is discussed The various parameters which induce damping are analyzed Mathematical models are developed to show the damping ratio and the equations of motion for viscous and hysteresis damping The test facilities and procedures for experimental determination of damping coefficients are reported
Author

N73-29918 Air Force Flight Dynamics Lab, Wright-Patterson AFB, Ohio
DESIGN AND SONIC FATIGUE CHARACTERISTICS OF COMPOSITE MATERIAL COMPONENTS
N D Wolf and M J Jacobson (Northorp Corp, Hawthorne Calif) In AGARD Symp on Acoustic Fatigue May 1973 18 p refs (For availability see N73-29905 20 32)
A summary of two programs concerned with the design and acoustic testing of composite material components is presented Equations are developed for both a simplified theory and a more general theory in matrix form for predicting natural frequencies, mode shapes and stresses in unstiffened and cross-stiffened advanced composite panels subjected to acoustic loads Sonic fatigue test results on simple 8-ply boron-epoxy and 6 ply cross-stiffened graphite-epoxy panels are described This includes panal damping values, fatigue life stress data and a description where appropriate, of panel fatigue failures Also a series of 72 beam specimens was fatigue tested with shaker excitation to develop S-N data for various simulated joint configurations The beams consisted of a graphite-epoxy or boron-epoxy material bonded or riveted to a graphite epoxy or titanium alloy stiffener S-N data up to 10 to the 8th power cycles were obtained Frequencies and strains predicted by the analytical procedures are compared with experimentally measured values
Author

N73-29919 Rohr Corp Chula Vista, Calif
SONIC FATIGUE OF DIFFUSION-BONDED TITANIUM SANDWICH STRUCTURE
I Holehouse In AGARD Symp on Acoustic Fatigue May 1973 p 15 p refs (For availability see N73-29905 20 32)
The sonic fatigue characteristics of titanium sandwich structures using a liquid interface diffusion (LID) bonding process are discussed Test panels were subjected to sound levels of up to 170 db for extended time periods Various failure modes and times to failure were observed Sufficient strain and acoustic data were taken to develop a semi empirical design analysis nomograph A single degree of freedom random response equation combined with a finite element approach for determining natural frequencies and static stress values was used The effect of skin repairs and facing to core bond voids were investigated by testing panels with programmed defects
Author

N73-29920 Aeritalia, Turin (Italy)
ACOUSTIC FATIGUE TEST ON THE VFW-FOKKER VAK 191 B STRUCTURAL COMPONENTS
Pietro Selvaggi and Angelo Lorea (Fiat S p A , Turin) *In* AGARD Symp on Acoustic Fatigue May 1973 16 p refs (For availability see N73-29905 20-32)
Near field noise and temperature measurements on 1/4 scale model of the VFW-FOKKER VAK 191 B aircraft indicated that critical environments will be induced on aircraft structural components during the VTO and STO configurations The results of the structural response and endurance test performed on a fuselage skin panel and on a wing trailing edge flap are reported The noise and temperature simulation procedure and the experimental facilities arranged for testing purpose are described Author

N73-29921 Royal Aircraft Establishment, Farnborough (England) Structures Dept
SOME CONSIDERATIONS OF THE FATIGUE BEHAVIOUR OF ALUMINUM ALLOY STRUCTURES UNDER ACOUSTIC LOADING
W T Kirkby *In* AGARD Symp on Acoustic Fatigue May 1973 14 p refs (For availability see N73-29905 20-32)
Data on the fatigue performance of aluminum alloy structural elements which represent typical skin-stringer attachments, or integrally-milled skin-stiffener configurations, for use in design against acoustic fatigue are discussed The fatigue data have generally been obtained from tests under narrow-band random loading with zero mean stress in the skin Some guidance is given on the allowances which should be made for differences in bandwidth and for effects of mean stress, when using such acoustic fatigue data The tentative advice given is based on general experience of the fatigue behaviour of other types of structural elements under a wider range of random loading conditions Some consideration is also given to some aspects of crack propagation under acoustic fatigue loading In particular the problem of crack propagation under combined fatigue loading actions is discussed Predictions of crack growth under cabin pressurisation and acoustic loading are used to illustrate the significance of the problem with reference to aircraft structures which must satisfy fail-safe requirements Author

N73-29922 Hawker Siddeley Aviation, Ltd Brough (England)
ASSESSMENT OF SIREN TEST TECHNIQUES
Eric James Phillips *In* AGARD Symp on Acoustic Fatigue May 1973 18 p refs (For availability see N73-29905 20-32)
The siren as a test technique for the determination of response and life of aircraft structures subject to engine noise field excitation is discussed A flat panel specimen is to be placed in the near noise field of a typical jet engine and its stress response measured The specimen is placed in a siren and the response which was measured in the engine noise field reproduced as closely as possible The differences in response is assessed with regard to the extrapolation of measured siren fatigue life to service environments Specimen responses in the engine noise field and in the siren are compared with the theoretically predicted response using methods of varying complexity Author

N73-29923 Air Force Flight Dynamics Lab , Wright-Patterson AFB, Ohio
SONIC FATIGUE RESISTANCE OF LIGHTWEIGHT AIRCRAFT STRUCTURES
R C W VanderHeyde and A W Kolb *In* AGARD Symp on Acoustic Fatigue May 1973 [illegible] p refs (For availability see N73 29905 20 32)
An experimental program under which the response and sonic-fatigue resistance of lightweight aircraft structures were investigated is presented The program involved a series of aluminum alloy panels of bonded beaded and skin stringer design A total of 60 bonded beaded and 60 skin-stringer type test specimens was investigated The panels were tested in groups of 5 or 10 at 4 different overall sound pressure levels to obtain test results with a high level of confidence The data reported include mode shapes panel damping ratios linearity of response, fatigue life and failure location For some panel configurations data to above 10 to the 8th power cycles were obtained The test facility, test fixture, noise source, testing technique, and instrumentation used, are described along with the test results. Fatigue failure detection techniques are discussed The test results are compared with stress predictions from various available methods Author

N73-29924# Advisory Group for Aerospace Research and Development, Paris (France)
FATIGUE LIFE PREDICTION FOR AIRCRAFT STRUCTURES AND MATERIALS
May 1973 223 p refs
(AGARD-LS-62) Avail NTIS HC $13 25
Procedures for predicting the fatigue life of aircraft structures are described The subjects discussed are (1) methods of stress measurement analysis for fatigue life evaluation (2) application of fracture mechanics principles in design and analysis of aircraft structures, (3) effects of corrosion fatigue, (4) crack growth prediction techniques, and (5) development of analytic theory for fatigue For individual titles, see N73-29925 through N73-29934

N73-29925 National Aerospace Lab , Amsterdam (Netherlands)
ASPECTS OF AERONAUTICAL FATIGUE
J Schijve *In* AGARD Fatigue Life Prediction for Aircraft Struct and Mater May 1973 23 p refs (For availability see N73 29924 20 32)
The evaluation of the fatigue quality of an aircraft is discussed Several steps, such as (1) determination of the fatigue load environment, (2) response of the aircraft structure, (3) internal load distributions and (4) estimation of the fatigue properties are involved The fatigue properties comprise fatigue life, crack propagation and residual strength The latter two items together with inspection procedures are qualifying the fail-safety The above aspects are analyzed with reference to the contributions of design efforts, calculations, testing inspections and fatigue load monitoring Author

N73-29926 Laboratorium fuer Betriebsfestigkeit, Darmstadt (West Germany)
METHODS OF STRESS-MEASUREMENT ANALYSIS FOR FATIGUE LIFE EVALUATION
O Buxbaum *In* AGARD Fatigue Life Prediction for Aircraft Struct and Mater May 1973 19 p refs (For availability see N73-29924 20-32)
The possibilities and limitations of a spectral presentation of measured stress-time histories are described A concept is presented which distinguishes between stresses due to random vibrations and stresses due to manoeuvers variations of payload, and which is suitable for any theoretical or experimental fatigue life evaluation Reference is made also to fatigue testing under random loading and to the derivation of external loads Author

N73-29927 Hawker Siddeley Aviation Ltd Hatfield (England)
THE USE OF COUNTING ACCELEROMETER DATA IN FATIGUE LIFE PREDICTIONS FOR AIRCRAFT FLYING IN COMPLEX ROLES
J A B Lambert *In* AGARD Fatigue Life Prediction for Aircraft Struct and Mater May 1973 18 p refs (For availability see N73 29924 20 32)
The use of counting accelerometer data for predicting the fatigue life of aircraft flying in various load conditions is discussed Methods for conducting a full scale fatigue test are explained The application of load and acceleration relationships for fighter and transport aircraft is analyzed The characteristics of fatigue meters for obtaining accurate load data are described Author

N73-29928 Air Force Flight Dynamics Lab Wright Patterson AFB Ohio
THE USE OF FRACTURE MECHANICS PRINCIPLES IN THE DESIGN AND ANALYSIS OF DAMAGE TOLERANT AIRCRAFT STRUCTURES
Howard A Wood *In* AGARD Fatigue Life Prediction for Aircraft Struct and Mater May 1973 13 p refs (For availability see N73 29924 20 32)

Current trends in the usage of high strength structural materials for aerospace applications are reviewed. The manner in which fracture control procedures may be implemented to achieve a higher degree of damage tolerance are discussed. The application of fracture requirements to two current designs is related. These experiences have contributed to the formulation of specifications for use across the board on all new systems. Important aspects of the proposed USAF damage tolerance criteria, including initial damage assumption and crack growth analyses, are discussed. Author

N73-29929 Battelle-Northwest, Richland, Wash.
CORROSION FATIGUE - OR - HOW TO REPLACE THE FULL SCALE FATIGUE TEST
W. E. Anderson *In* AGARD Fatigue Life Prediction for Aircraft Struct. and Mater. May 1973 10 p refs (For availability see N73-29924 20-32)

The effect of environment and stress-cycling in real-time on in-service structural failure is discussed. Comparative calculations of cracking from a fastener hole are used as the basis of the investigation. A method to overcome the limitations of full-scale fatigue test data is proposed. The method involves sacrificial examination of selected portions of airframes and testing of the structural materials under several environmental and stress histories. Application of the procedure for calculating scheduled repair times for individual airframes based on respective flight experiences is proposed. Author

N73-29930 Aeronautical Systems Div., Wright-Patterson AFB, Ohio.
ON FATIGUE ANALYSIS AND TESTING FOR THE DESIGN OF THE AIRFRAME
Walter J. Crichlow *In* AGARD Fatigue Life Prediction for Aircraft Struct. and Mater. May 1973 36 p refs (For availability see N73-29924 20-32)

The experimental and analytical techniques for controlling time to fatigue crack initiation in design of aircraft structure are reviewed to define improvements that may be gained from available research knowledge. Discrepancies among simple theory, experiment, and service are being better explained by accountability for residual stress systems created by higher than average loading peaks recurring randomly throughout the service load spectrum. Analytical accounting for the generation, decay, and recreation of residual stress spectra is an essential adjunct to the experimental approach for not all parts can be critically tested, and not all load spectra variations can be accommodated in test. Recent advances in residual stress analyses are reviewed. Failure theory, interaction matrix, chemical (corrosion), and mechanical (fretting) environmental aspects are explored. Variability of results are discussed in terms of design life reduction factors. Author

N73-29931 Battelle-Northwest, Richland, Wash.
A RATIONAL ANALYTIC THEORY OF FATIGUE REVISITED
W. E. Anderson *In* AGARD Fatigue Life Prediction for Aircraft Struct. and Mater. May 1973 9 p refs (For availability see N73-29924 20-32)

Fatigue of airframe structures is viewed from the standpoint of crack initiation and extension. By employing a rational analytic theory of fatigue, the aspect of crack extension is treated in terms of the maximum stress-field-parameter, and the minimum to maximum load excursion ratio. Initiation is treated as that period prior to development of a well-behaved crack. A number of airframe fatigue test data are thereby examined and compared with interpreted service experiences. The principal differences seem to stem from environmental influences in service that are not represented during laboratory experiments. Author

N73-29932 Air Force Flight Dynamics Lab., Wright-Patterson AFB, Ohio.
A SUMMARY OF CRACK GROWTH PREDICTION TECHNIQUES
Howard A. Wood *In* AGARD Fatigue Life Prediction for Aircraft Struct. and Mater. May 1973 31 p refs (For availability see N73-29924 20-32)

The use of material growth rate data and analytical retardation models in predicting crack growth under variable amplitude loading is reviewed. Retardation models of current interest are discussed and compared. An effective stress model is described, including the mathematical formulation, applicability and usage limitations. Comparison of analyses and tests for typical spectra are shown. A primary factor in the accurate prediction of spectrum crack growth behavior is the proper representation of basic growth rate data including consideration of R factor shift and possible limit, threshold levels of stress intensity, closure effects and environment. The relative significance of each of these parameters on total crack growth life is discussed. Author

N73-29933 Hawker Siddeley Aviation, Ltd., Hatfield (England).
THE R.Ae.S. - ESDU CUMULATIVE DAMAGE HYPOTHESIS
J. A. B. Lambert *In* AGARD Fatigue Life Prediction for Aircraft Struct. and Mater. May 1973 16 p refs (For availability see N73-29924 20-32)

The limitations of a cumulative damage hypothesis for estimating the fatigue life of airframes are described. The major source of error is identified as being due to neglecting the redistribution of stresses that occurs when a part yields at a stress concentration. A method which takes the localized yielding effects into account is proposed. The procedure involves estimating the change in the actual mean stress of subsequent stress cycles after yielding has occurred. Author

N73-29934 Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
FATIGUE LIFE PREDICTION: A SOMEWHAT OPTIMISTIC VIEW OF THE PROBLEM
Walter Schuetz *In* AGARD Fatigue Life Prediction for Aircraft Struct. and Mater. May 1973 32 p refs (For availability see N73-29924 20-32)

Lack of correlation between the fatigue life predicted from calculations and tests and the service life actually obtained is discussed. This may be due to one or several of the following causes: (1) incorrect load spectra were assumed in the calculations and applied in the tests including the full scale test, (2) Miner's Rule was used in the life calculations, (3) unexpected failures occurred, starting from material flaws in non redundant structure built of high strength materials, and (4) the load sequence in the tests including the full scale test was too much simplified. It is suggested that major improvements in the accuracy of fatigue life prediction should be possible using modern methods and modern data. These are compared to hitherto existing methods for life calculations in the design stage, for component testing and for the full scale fatigue test. Author

N74-15596# Advisory Group for Aerospace Research and Development, Paris (France).
SECOND SYMPOSIUM ON STRUCTURAL OPTIMIZATION
Nov. 1973 390 p refs Struct. and Mater. Panel Symp. held at Milan, 2-4 Apr. 1973
(AGARD-CP-123) Avail: NTIS HC $21.50

The symposium papers are presented with the major emphasis placed on methods which are already in or are rapidly nearing a practical operational status. The papers demonstrate a remarkable diversity of practical applications of the various approaches to structural optimization. For individual titles, see N74-15597 through N74-15617.

N74-15597 Brown Univ., Providence, R.I.
NECESSARY AND SUFFICIENT CONDITIONS FOR GLOBAL STRUCTURAL OPTIMALITY
W. Prager *In* AGARD Second Symp. on Structural Optimization Nov. 1973 12 p refs Sponsored by AROD (For availability see N74-15596 06-32)

A method is discussed by which necessary and sufficient conditions for global structural optimality can be derived for a wide variety of design constraints. The importance is stressed of conditions that are not only necessary but also sufficient for global optimality. To present the method, minimum mass design of a truss with prescribed elastic compliance is treated when

the truss is to be derived from a given basic layout and when the layout is left open Use of the method for other constraints, alternative states of loading and structures of other types is illustrated by examples Computational aspects of structural optimization are discussed Author

N74-15598 Bell Aerospace Co Buffalo N Y Structural Systems Dept

SURVEY OF THE STATE-OF-THE-ART OF OPTIMIZATION TECHNOLOGY WITHIN NATO COUNTRIES

Ronald A Gellatly *In* AGARD Second Symp on Structural Optimization Nov 1973 20 p refs (For availability see N74 15596 06 32)

The Working Group on Optimization of the Structures and Materials Panel AGARD as part of its continuing activity sponsored a survey of the state-of-the-art in structural optimization and automated design technology within NATO countries The results of meetings held with representatives of Italy, Germany, Holland Belgium France and Great Britain are presented along with submittals from Denmark Norway Canada and Portugal A brief survey of the state-of-the-art in the United States is also included Author

N74-15599 Air Force Flight Dynamics Lab, Wright-Patterson AFB Ohio Synthesis Group

APPLICATION OF OPTIMALITY CRITERIA APPROACHES TO AUTOMATED DESIGN OF LARGE PRACTICAL STRUCTURES

V B Venkayya N S Khot and L Berke *In* AGARD Second Symp on Structural Optimization Nov 1973 19 p refs (For availability see N74 15596 06 32)

A unified approach for the derivation of optimality criteria for the design of optimum structures is presented The design conditions included requirements of generalized stiffness specified displacements dynamic stiffness and stiffness for general stability Recursion relations for achieving the optimality criteria are derived for all these cases Both single and multiple stiffness requirements are considered The formulation considers isotropic anisotropic and layered composite structures Four categories of design examples are selected to illustrate the versatility of the method The first group is designed for static loads with constraints on stresses displacements and minimum sizes The second group of examples is designed for dynamic loads with periodic time dependence The third group consists of layered composite structures subjected to static loads The fourth group is concerned with static stability requirements The results of many of these examples are compared with those available in the literature Author

N74-15600 Case Western Reserve Univ Cleveland Ohio

RECENT DEVELOPMENTS IN THE CASE OPTIMIZATION PROGRAM

Fred Moses *In* AGARD Second Symp on Structural Optimization Nov 1973 8 p refs (For availability see N74 15596 06 32)

Three optimization problem types and respective solutions are identified A penalty function approach is used for design of elements such as welded girders columns prestressed concrete beams and simple gabled frames which have complex design code constraints but relatively few design variables The second problem type includes a modified Zoutendijk feasible direction method and has been used for structural system constraints such as deflection stability and flutter The third problem type includes discrete variables involving sizes inventory and fabrication costs and can often be handled by dynamic programming The influence of optimum design on safety and reliability remains a continuing area of research and models of reliability analysis and design are discussed Author

N74-15601 Liverpool Univ (England) Dept of Civil Engineering

STRUCTURAL DESIGN APPLICATIONS OF GEOMETRIC PROGRAMMING

A B Templeman and S K Winterbottom *In* AGARD Second Symp on Structural Optimization Nov 1973 16 p refs (For availability see N74 15596 06 32)

The technique of geometric programming is described for the solution of non-linear optimization problems The form in which the method was first developed now usually known as prototype geometric programming is presented in some detail and this is followed by a description of more recent developments which have considerably extended the scope and usefulness of the method It is demonstrated that many problems arising in optimum structural design may be formulated in such a way as to be easily and rapidly solved using geometric programming Finally the problem of designing minimum weight space trusses to satisfy stress and deflection constraints is examined and it is shown that by using a further extended approximate form of geometric programming optimum designs may be derived iteratively using only a few cycles of analysis and iteration Author

N74-15602 Royal Aircraft Establishment Farnborough (England) Structures Dept

THE OPTIMISATION OF STATICALLY INDETERMINATE STRUCTURES BY MEANS OF APPROXIMATE GEOMETRIC PROGRAMMING

A J Morris *In* AGARD Second Symp on Structural Optimization Nov 1973 17 p refs (For availability see N74 15596 06 32)

Application of approximate geometric programming in the least weight design of statically indeterminate structures is described It is shown how the facility of standard geometric programming to obtain bounds on a minimum weight design is preserved The advantages of coupling geometric programming with a modern projected gradient method are also described Numerical examples which are used to illustrate the method involve up to two load conditions with active constraints on stresses and displacements Author

N74-15603 Middle East Technical Univ Ankara (Turkey)

APPLICATION OF DISCRIMINATE FUNCTION TECHNIQUE TO RANDOM SEARCH

M O Kiciman and M Akguel *In* AGARD Second Symp on Structural Optimization Nov 1973 10 p refs (For availability see N74 15596 06 32)

Statistical methods of discrimination were used as a decision making tool in nonlinear constrained optimization problems A linear discriminant function form is proposed as an aid to the preliminary designer It is assumed that a design problem with a large number of variables is given and only an approximate answer that will aid the decision maker is required The possibility is discussed of representing each design point in a reduced design space by means of pooling the variables The optimization procedure based on a combination of direct search and discriminant function method was applied to typical test problems and to a grid design problem The grid has a stiffness dependent loading condition with cost function not directly dependent on some of the design variables This particular choice was made in order to illustrate the complete generality of the method Author

N74-15604 Istituto di Elaborazione dell'Informazione Pisa (Italy)

INTEGER PROGRAMMING ALGORITHMS FOR OPTIMUM STRUCTURAL DESIGN

Aldo Cella *In* AGARD Second Symp on Structural Optimization Nov 1973 14 p refs (For availability see N74 15596 06 32)

A large variety of structural design problems is constrained by the practical necessity of selecting the design parameters from an enumerable set of discrete values The resulting solution space has a grid-like pattern and an enumerative combinatorial algorithm seems most appropriate for the problem A branch and bound algorithm was developed for the optimal design of a large class of linearly elastic structures discretized into finite elements and subjected to stress deflection and stiffness constraints Sensitivity coefficients were developed for all those constraints The algorithm is of the enumerative kind having decision rules that are specific to the solution space associated with structural problems The resulting numerical procedure was applied to the optimal design of a number of aerospace type structures such as the hammerhead of a large scale radiotelescope and the supporting structure of an orbiting telescope mirror Author

N74-15605 Politecnico di Milano (Italy)

SHAPE OPTIMIZATION USING MATHEMATICAL PROGRAMMING AND MODELLING TECHNIQUES

Edmondo Vitiello *In* AGARD Second Symp on Structural Optimization Nov 1973 11 p refs (For availability see N74 15596 06 32)

Structural optimization of elastic models with design variables describing their geometry is considered The use of mathematical programming for practical design is shown in connection with a progressive (quadratic) fitting of the constraints in the space of design variables (modelling) The method proves successful for a few design variables and for smooth variations of stresses and loads with the design variables However it seems to make feasible the use of optimization for practical design in some fields where earlier optimization methods implied very heavy calculations Applications to the optimum design of gravity dams, considering both their static (finite element analysis) and dynamic (seismic) behavior is presented Author

N74-15606 Cranfield Inst of Technology (England) Coll of Aeronautics

THE DESIGN OF COMPATIBLE STRUCTURES

D M Richards *In* AGARD Second Symp on Structural Optimization Nov 1973 13 p refs (For availability see N74 15596 06 32)

A format for the economical description of complex structures for design purposes is introduced Sufficient conditions under which a redundant configuration may be fully stressed are formulated These conditions are used to determine a wide range of simple frameworks with this property Some characteristics of sequential redesign trajectories are described utilizing the format Author

N74-15607 Cornell Univ Ithaca N Y Dept of Structural Engineering

OPTIMIZATION OF STIFFENED PANELS

R H Gallagher and W E Falby *In* AGARD Second Symp on Structural Optimization Nov 1973 14 p refs (For availability see N74 15596 06 32)

A program is described for the structural optimization of longitudinally stiffened plates loaded in compression The complexity of the problem is reduced significantly by exploiting the understanding of the initial buckling and postbuckling behavior of these panels in order to reduce the number of inequality constraint conditions An interior penalty function technique is combined with an unconstrained optimization algorithm to produce an efficient optimization program Results generated by the program are compared with relevant data from design charts Author

N74-15608 Technical Univ of Denmark Lyngby Dept of Solid Mechanics

OPTIMAL JOINT POSITIONS FOR SPACE TRUSSES

Pauli Pedersen *In* AGARD Second Symp on Structural Optimization Nov 1973 14 p ref (For availability see N74 15596 06 32)

An iterative procedure is presented for determining the joint positions corresponding to a minimum mass space truss Displacement constraints and non constant stress constraints (stability) are taken into account The truss is presumed to carry consecutively a large number of different systems of forces The iteration includes a sequence of linear programming problems (SLP with move limits) and for each of these problems only the nearby constraints are considered Analytical expressions are given for the gradients describing the linear problems Author

N74-15609 Stanford Univ Calif Dept of Aeronautics and Astronautics

APPLICATION OF A GENERAL METHOD FOR FLUTTER OPTIMIZATION

R F Taylor (AFFDL) and L B Gwin *In* AGARD Second Symp on Structural Optimization Nov 1973 14 p refs (For availability see N74 15596 06 32)
(Contracts F33615 70 C 1282 F33615 72 C 1275)

Design of modern aircraft requires that aeroelastic considerations be included as early as possible to avoid addition of excessive weight for prevention of aeroelastic instabilities A computational approach for minimum weight design of flutter critical lifting surfaces is presented which has generality in the selection of analysis methods and demonstrated applicability to problems involving a large number of design variables A key feature of the method is the calculation of derivatives of the flutter speed with respect to design parameters These analytically derived derivatives are computed in such a way that they are economical for large scale problems The mathematical programming method which utilizes these derivatives is based on the method of feasible directions with a simplex algorithm to solve a linearized direction finding problem Results are presented which show that the method can efficiently reduce the structural weight of lifting surface designs involving at least 99 design variables Author

N74-15610 Bell Aerospace Co Buffalo N Y Structural Systems Dept

MINIMUM WEIGHT DESIGN OF SURFACE EFFECT VEHICLES USING THE SIEVE-SEARCH TECHNIQUE

James R Batt and Ronald A Gellatly *In* AGARD Second Symp on Structural Optimization Nov 1973 14 p refs (For availability see N74 15596 06 32)
(Contract MA-4687)

Past and present methods for the optimization of structural systems for minimum weight use mathematical programming or numerical search techniques This procedure has lead to an intractable situation whereby large computer costs and mathematical complexity arises More economical and more flexible procedures for structural optimization of large scale systems have therefore been sought A new approach to determine the minimum weight of such systems has been developed and is labeled the sieve search technique In performance of optimization studies using this technique the guiding philosophy was to generate an optimal arrangement of preoptimized components An essential element of the technique is the use of data banks which contain minimum weight and associated geometry of the structural components These banks are generated using classical methods of optimization An additional facet of the technique is the use of simplified engineering analysis methods during the redesign phase of the optimization cycle Author

N74-15611* National Aeronautics and Space Administration Langley Research Center Langley Station Va

AUTOMATED SIZING OF LARGE STRUCTURES BY MIXED OPTIMIZATION METHODS

Jaroslaw Sobieszczanski and David Loendorf (Army Air Mobility R and D Lab) *In* AGARD Second Symp on Structural Optimization Nov 1973 12 p refs (For availability see N74 15596 06 32)

A procedure for automating the sizing of wing fuselage airframes was developed and implemented in the form of an operational program The program combines fully stressed design to determine an overall material distribution with mass strength and mathematical programming methods to design structural details accounting for realistic design constraints The practicality and efficiency of the procedure is demonstrated for transport aircraft configurations The methodology is sufficiently general to be applicable to other large and complex structures Author

N74-15612 British Aircraft Corp Preston (England) Military Aircraft Div

OPTIMISATION OF AIRCRAFT STRUCTURES WITH MULTIPLE STIFFNESS REQUIREMENTS

I C Taig and R I Kerr *In* AGARD Second Symp on Structural Optimization Nov 1973 14 p refs (For availability see N74 15596 06 32)

A general optimality theorem is presented for structures whose members have stiffnesses proportional to their masses and which are designed by generalized stiffness requirements The theorem is used to derive an iterative procedure for optimum structure design Modifications to the basic theorem enable practical constraints such as minimum material gauges and strength or stability requirements to be introduced The method [illegible] be used where stiffness requirements are directly specified for [illegible] loading

conditions or where vibration frequency or aeroelastic efficiency requirements are stipulated A useful feature of the method when used in conjunction with automated design procedures is that the optimization can operate with real structure variables and constraints so that there is no subsequent design operation required to convert idealised structure dimensions to feasible detail sizes Several examples are quoted to show that very favorable results and computing times are obtainable for demonstration problems The ability to handle major structural optimization is also illustrated by applications to actual airframe structures Author

N74-15613 Grumman Aerospace Corp, Bethpage, N Y Structural Mechanics Section
APPLICATION OF A DESIGN ANALYSIS SYSTEM TO A SPACE SHUTTLE PRELIMINARY DESIGN c31
W Lansing, P Mason, W Dwyer and J C Cooper *In* AGARD Second Symp on Structural Optimization Nov 1973 14 p refs (For availability see N74-15596 06-32)

In a broad sense interdisciplinary design analysis systems are optimization tools, of which the specialized computer programs which resize structures of fixed topology are merely a part This interrelationship is portrayed by describing briefly the Integrated Design Analysis System (IDEAS) and showing how its Automated Structural Optimization Program (ASOP) is incorporated within the basic system Application to a preliminary design of the space shuttle is presented and ways in which ASOP is being improved are discussed Author

N74-15614 Messerschmitt-Boelkow-Blohm G m b H Hamburg (West Germany) Stress Dept
OPTIMIZATION AND DESIGN OF THE REAR FUSELAGE OF THE A 300 B AIRCRAFT STRUCTURE c02
D Schulz *In* AGARD Second Symp on Structural Optimization Nov 1973 15 p refs (For availability see N74-15596 06-32)

A method is described for the automatically controlled calculation of a skin stringer structure The method was programmed and applied for the first time for the development of the Airbus A 300 B The method can be considered as a link in a process chain, the target of which is the overall development of aircraft structures It starts with the calculation of statically indeterminate forces and ends up with the statical strength analysis Input and output data for the calculations of statically indeterminate forces are used as input data for structure dimensioning or strength analysis program The structure dimensioning program iterativly modifies the originally defined wall thicknesses so that the reserve factors required to prevent failure under tensile, compression and shear loads are reached or only slightly exceeded in all critical load cases The originally defined structural concept (stringer and frame spacing as well as stringer shapes) is not changed in this case Final dimensioning is influenced by manufacturing considerations On completion of the dimensioning work the dimensions are laid down and the strength analysis is carried out in a single computer run The flow of the program is demonstrated in the example of the Airbus A 300 B rear fuselage Author

N74-15615 Chantiers de l'Atlantique Saint Nazaire (France)
THE DOUBLE ITERATION METHOD IN STRUCTURAL OPTIMIZATION
Daniel H Finifter *In* AGARD Second Symp on Structural Optimization Nov 1973 10 p refs (For availability see N74-15596 06-32)

Most structural optimization processes require a large number of iterations to be performed, involving at each step a detailed stress analysis of the current design Considering that a gross analysis is comparatively very economical it is possible to perform most iterations on a simplified mesh with only occasional refined analyses to correct the mismodeling effects Although the overall number of steps referred to as primary iterations necessary to achieve the optimum is then higher than by conventional procedures only those involving a detailed analysis or secondary iterations are significant timewise That double iteration scheme was employed in determining the minimum weight design, assumed to be fully stressed, of a tanker web frame, using the stress ratio method Satisfactory convergence was reached after 2 secondary iterations whereas by standard calculations 8 to 10 would have normally been required Author

N74-15616 Technische Hochschule Aachen (West Germany) Inst fuer Leichtbau
HOMOLOGOUS DEFORMATION OF STIFFENED SHELLS FOR RADIO TELESCOPE STRUCTURES
J F Kowalewski and H A Ziebarth *In* AGARD Second Symp on Structural Optimization Nov 1973 13 p refs (For availability see N74-15596 06-32)

In radio telescopes all surface elements have to reflect incoming radio waves to a defined focus, i e the surface should be an exact paraboloid As a telescope has to be tilted elastic deformations caused by rotating the telescope about a horizontal axis are invitable But these deformations should be homologous i e should change only the position of the focus, the focal length and the axis of the paraboloid The report deals with the homology conditions for the displacements and the rotations of the tangents of the surface and the change of the parameters of the paraboloid It is shown how to find the optimum design of a reflector shell, which complies with these homology conditions Author

N74-15617 Technische Univ Berlin (West Germany) Inst of Aeronautics and Astronautics
OPTIMIZATION OF THE LAYOUT OF TRUSSES COMBINING STRATEGIES BASED ON MICHELL'S THEOREM AND ON THE BIOLOGICAL PRINCIPLES OF EVOLUTION
A Hoefler U Leysser and J Wiedemann *In* AGARD Second Symp on Structural Optimization Nov 1973 8 p refs (For availability see N74-15596 06-32)

A method developed for finding the optimum layout of plane trusses is reviewed Both strategies employed are described in some detail giving special attention to the problem of selecting the proper set of points at the beginning of the optimization process An example of the application of the evolution strategy is given When both strategies are combined, having each one perform the function in the optimization process it is best suited for their specific disadvantages can be eliminated Thus an initial design is found using linear programming while the evolution strategy is used to find better positions of the joints This constitutes one cycle of optimization More cycles will follow if the improved positions of the joints require a change in the set of the optimum bars The problem of a cantilever truss loaded at the tip is solved using the combined strategies The optimum structure for this case being known a comparison is made showing the efficiency of the method Author

N74-19660# Advisory Group for Aerospace Research and Development Paris (France)
ACOUSTIC FATIGUE DESIGN DATA, PART 3
A G R Thomson (Eng Sci Data Unit Ltd) and R F Lambert (Eng Sci Data Unit Ltd) Dec 1973 62 p refs (AGARDograph 162 Pt 3 AGARD AG 162 Pt 3) Avail NTIS HC $6.25

The design criteria for aircraft structural elements to reduce the effects of acoustic fatigue are discussed The subjects presented are (1) endurance of titanium and titanium alloy structural elements subjected to simulated acoustic loading (2) damping in acoustically excited structures (3) reference frequency of panel with flexible stiffeners and (4) estimation of stress in skin panels with flexible stiffeners subjected to random acoustic loading Author

33 THERMODYNAMICS AND COMBUSTION

Includes ablation, cooling, heating, heat transfer, thermal balance, and other thermal effects, and combustion theory For related information see also 12 Fluid Mechanics, and 27 Propellants

N71-25368# Advisory Group for Aerospace Research and Development, Paris (France)
THERMOPHYSICAL PROPERTIES OF SOLID MATERIALS: COOPERATIVE THERMAL EXPANSION MEASUREMENTS UP TO 1000 C PROJECT SECTION 1A
E Fitzer Mar 1971 65 p refs
(AGARD-AR-31-71) Avail NTIS

Pushrod dilatometer measurements to 1000 C as carried out by employing samples having the same history were evaluated both statistically and with regard to the nature of the errors involved Using high purity gold and platinum as selected reference materials, it was found that the relative pushrod dilatometer measurements when used in a group effort can yield an accuracy equal to that obtained by individual absolute measurements. This result was confirmed with engineering materials such as an austenitic alloy, a Ta/10 W alloy, sintered alumina and fine grain graphites Author

N72-12950# Advisory Group for Aerospace Research and Development, Paris (France) Propulsion and Energetics Panel
HEAT TRANSFER IN ROCKET ENGINES
H Ziebland (Explosives Res and Develop Estab) and R C Parkinson (Rocket Propulsion Estab) Sep 1971 160 p refs
(AGARD-AG-148-71, AGARDograph-148) Avail NTIS

Basic heat transfer processes are considered simple convective heat transfer from hot gases to the engine walls under various conditions, radiation heat transfer and coolant heat transfer processes Methods of cooling used in liquid propellant rocket engines, such as regenerative film ablation and radiation cooling are discussed The properties of materials that must be known by the engine designer from the transport properties of the hot combustion gases to those of the materials from which the engine will be constructed Emphasis was placed on presenting simple methods for calculating the magnitude of heat transfer Author

N72-18946# Advisory Group for Aerospace Research and Development Paris (France)
HEAT EXCHANGERS
Jean J Ginoux, ed Jan 1972 97 p refs
(AGARD-LS-57) Avail NTIS

Problems associated with the design, testing and use of heat exchangers are discussed with respect to compact heat exchangers used in turbine regenerators and aerospace vehicles, heat exchangers in the process and power industries, and heat exchangers with liquid metals For individual titles, see N72-18947 through N72-18949

N72-18947# Stanford Univ, Calif
COMPACT HEAT EXCHANGERS
William M Kays *In* AGARD Heat Exchangers Jan 1972 22 p refs (See N72-18946 09-33)
Avail NTIS

The design and application of heat exchangers employing surface arrangements having the characteristics of very large amounts of surface heat transfer area per unit of volume are considered Relationships between the friction power expended and the heat transferred are explored and methods of improving the performance of heat exchanger surfaces are investigated Heat exchanger design theory, to the extent that it is applicable to very compact exchangers, is reviewed Data are presented on the heat transfer and friction behavior of a number of very compact surfaces. Author

N72-18948# European Atomic Energy Community, Ispra (Italy) Technology Div
HEAT EXCHANGE AND HEAT EXCHANGERS WITH LIQUID METALS
R Nijsing *In* AGARD Heat Exchangers Jan 1972 61 p refs (See N72-18946 09-33)
Avail NTIS

Forced convection, liquid metal heat transfer is discussed The physical principles underlying single phase, liquid metal heat transfer theory is outlined, and the significant developments of the past decade are described Flow and heat transfer aspects associated with uniform channels (tubes, parallel plates, annuli) are considered first This provides the ground for a basic discussion of flow and heat transfer in rod bundle geometries and of topics of engineering interest including thermal design of liquid metal cooled nuclear fuel rod assemblies and thermal analysis of liquid metal heat exchangers Emphasis throughout is on a basic approach In theoretical considerations particular attention is paid to turbulent transport characteristics in the coolant and to the methodology underlying heat transfer computation procedures Author

N72-18949# National Engineering Lab, East Kilbride (Scotland)
INDUSTRIAL HEAT EXCHANGERS
D Chisholm W Drummond (Babcock and Wilcox Ltd, London), and I Murray *In* AGARD Heat Exchangers Jan 1972 9 p refs (See N72-18946 09-33)
Avail NTIS

Various types of heat exchangers used in the process industries are considered Specifically the design of the following heat exchangers are discussed shell-and-tube heat exchangers, condensers, evaporators and reboilers, plate heat exchangers, air coolers, cooling towers, evaporative coolers, and direct contact heat exchangers Author

N72-24959# Advisory Group for Aerospace Research and Development, Paris (France)
ABLATION
H Hurwicz, K M Kratsch, J E Rogan, and R E Wilson, ed (NOL White Oak, Md) Mar 1972 55 p refs
(AGARD-AG-161) Avail NTIS HC $4.75

Physico-mathematical approaches to analysis of ablation processes are brought out, ranging from a simplistic heat of ablation concept to the sophisticated analysis of laminar and turbulent flow, nonequilibrium ablation in chemically reacting flow fields, including surface reactions, and radiative heat transfer Emphasis is given to the synergistic mechanisms occurring during ablation Examples of nosetip interaction with the aero-thermodynamic environment at the surface and at depth are given and striation phenomena on the afterbody are discussed Material property and environmental effects on material performance are also reviewed, as well as the test simulation requirements Requirements for further studies of mechanical erosion other synergistic effects and extension of facilities range of performance are also noted Author

N72-24960# Advisory Group for Aerospace Research and Development, Paris (France)
THERMOPHYSICAL PROPERTIES OF SOLID MATERIALS PROJECT SECTION 1B THERMAL EXPANSION MEASUREMENTS FROM 1000 C TO 2600 C
E Fitzer Feb 1972 60 p refs
(AGARD-AR-38) Avail NTIS HC $5.00

The thermal expansion behavior of selected materials above 1000 C was determined experimentally Pure platinum, sintered Al2O3 sintered and arc cast tungsten Ta/10W alloy, and three types of polycrystalline graphites (AXM 5Q, RVD, AAQ1), each

from the same original stock, were used as sample materials. Several experimental techniques, such as twin microscopic measurements, push rod methods and X-ray studies were applied. All experimental results were analyzed for the possible error causes, and conclusions were drawn with respect to the accuracy of experimental data obtained by the different methods, as well as for the suitability of the sample materials for such measurements. Author

N73-20945# Advisory Group for Aerospace Research and Development, Paris (France).

HEAT-TRANSFER MEASUREMENTS IN SHORT-DURATION HYPERSONIC FACILITIES

D. L. Schultz (Oxford Univ.) and T. V. Jones (Oxford Univ.) Feb. 1973 155 p refs

(AGARD-AG-165; AGARDograph-165) Avail: NTIS HC $9.75

The techniques for making measurements of heat transfer in short duration and rapidly varying flows are reviewed. Methods discussed include: gauges operating on the semi-infinite principle, calorimeter gauges, pyroelectric heat transfer gauges, measurement of radiative heat transfer, and optical methods. The error in deduced heat transfer rate arising from a surface temperature discontinuity due to the presence of an isolated heat transfer gauge is also discussed. F.O.S.

N73-25968# Advisory Group for Aerospace Research and Development, Paris (France).

THERMOPHYSICAL PROPERTIES OF SOLID MATERIALS. PROJECT SECTION 2: COOPERATIVE MEASUREMENTS ON HEAT TRANSPORT PHENOMENA OF SOLID MATERIALS AT HIGH TEMPERATURE

E. Fitzer (Karlsruhe Univ., West Germany) Mar. 1973 113 p refs

(AGARD-R-606; AGARD-606) Avail: NTIS HC $7.75

Measurements of heat transfer properties of solid materials at high temperatures are discussed. The range between 1,000 C and 3,000 C is examined. It is stated that exact information on the thermophysical properties of materials and on the temperature dependence must be considered as a precondition for the calculation of the behavior of structural elements during service, especially with respect to transient heating and cooling. Mathematical models are provided to quantify the heat loss characteristics. Specific materials are analyzed to determine their thermodynamic properties. Author

34 GENERAL

Includes information of a broad nature related to industrial applications and technology, and to basic research, defense aspects, information retrieval, management, law and related legal matters, and legislative hearings and documents.

N71-23501# Advisory Group for Aerospace Research and Development Paris (France)
SCIENTIFIC AND TECHNICAL INFORMATION: WHY, WHICH, WHERE, AND HOW ? Lecture Series
Feb 1971 65 p refs Conf Presented in Oslo 2 3 Nov 1970, sponsored by the Tech Inform Panel and the Consultant and Exchange Programme of AGARD Also Presented in Rome 5 6 Nov 1970
(AGARD-LS-44) Avail NTIS

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3 USER NEEDS J F Stearns (NASA Washington D C) 6 p (See N71-23504 12-34)

4 SOURCES OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION H A Stolk (Natl Aerospace Lab Amsterdam Neth 13 p refs (See N71-23505 12-34)

5 SELECTIVE DISSEMINATION OF INFORMATION A SYSTEM REVIEW S C Schuler (Min of Technol Orpington Engl) 22 p refs (See N71 23506 12-05)

6 CONCEPT MISSION AND OPERATION OF SCIENTIFIC AND TECHNICAL INFORMATION ANALYSIS CENTERS G S Simpson Jr and J W Murdock (Battelle Mem Inst Columbus Ohio) 14 p (See N71-23507 12-34)

N71-23502# National Aerospace Lab Amsterdam (Netherlands)
INTRODUCTORY PAPER
H A Stolk *In* AGARD Sci and Tech Inform Feb 1971 3 p refs (See N71-23501 12-34)
Avail NTIS

Information systems and their histories are briefly discussed along with subjects to be covered in the current lecture series. In this series the product considered was the technological information that exists in the form of printed words graphs tables, pictures, specifications etc and means by which this information can be transferred. Also discussed in the introductory speech is the transfer of technology and its management. A L

N71-23503# Defence Scientific Information Service Ottawa (Ontario)
WHAT CAN INFORMATION DO FOR YOU ?
Alice M Ironside *In* AGARD Sci and Tech Inform Feb 1971 7 p refs (See N71-23501 12-34)
Avail NTIS

A philosophical non-technical approach is used to demonstrate that information is both an inherent part of life and a part of the fabric of living and that information is being presented to the individual continuously throughout his life by his own senses by other people and by the various media of communication. Also that this information may be unheeded or heeded and stored in his memory or may be stored in suitable forms by mechanical electronic and other means. Once stored, it may be later retrieved and applied to any appropriate purpose. Information is increasingly being recognized as a prime resource and the problems of maintaining the store of this resource and of its exploitation are being recognized and solutions sought. Author

N71-23504*# National Aeronautics and Space Administration Washington, D C
USER NEEDS
John F Stearns *In* AGARD Sci and Tech Inform Feb 1971 6 p (See N71-23501 12-34)
(NASA-TM-X-67142) Avail NTIS CSCL 05B

The question of user needs is examined from three viewpoints what has been and is being done to determine actual user needs the kinds of services now evolving to satisfy these needs and possible further steps to improve both definition and satisfaction of these needs. Attention is given to general areas of bibliographic services and to specific opportunities inherent in these services for the application of techniques and procedures that may provide potential users with easier access to a wider range of informational alternatives. Author

N71-23505# National Aerospace Lab Amsterdam (Netherlands)
SOURCES OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION
H A Stolk *In* AGARD Sci and Tech Inform Feb 1971 13 p refs (See N71-23501 12-34)
Avail NTIS

Attention is paid to the information environment the information explosion and the user and his behavior. Informal channels and formal services for obtaining information are discussed. A short description is also given of the problems in information retrieval. Author

N71-23506# Ministry of Technology Orpington (England) Reports Centre for Science and Technology
SELECTIVE DISSEMINATION OF INFORMATION A SYSTEM REVIEW
S C Schuler *In* AGARD Sci and Tech Inform Feb 1971 22 p refs (See N71-23501 12-34)
Copyright Avail NTIS

Selectivity is an essential factor in the transfer of information and the Selective Dissemination of Information (SDI) is a technique for providing individual users or groups of users with announcements of a limited number of documents specifically of interest to them. For large systems selection of relevant documents is achieved by a computer program which compares a file of bibliographic data on current reports journals articles etc with the interest profile of the SDI user. The selected references can be provided to the user in card form useful for filing or as a computer printed listing containing the main document bibliographic data descriptor terms and in some cases a short abstract. A review was made of various automated systems which have developed in North America and Europe during recent years. Some experiences of both large and small SDI systems are discussed and detailed aspects such as profile construction cost benefits and economics and user surveys are considered. As an alternative to printed output an outline is given of a system using on-line access to a central information store enabling the user to have selected references displayed visually at his remote console. Author

N71-23507# Battelle Memorial Inst Columbus Ohio
CONCEPT, MISSION, AND OPERATION OF SCIENTIFIC AND TECHNICAL INFORMATION ANALYSIS CENTERS
G S Simpson Jr and J W Murdock *In* AGARD Sci and Tech Inform Feb 1971 14 p (See N71-23501 12-34)
Avail NTIS

Information Analysis Centers (IAC's) are discussed in three parts concept mission and operation. Since there is an array of existing scientific and technical information services varying from the conventional library through special libraries and document depots to IAC's the presentation considers what an IAC is, how it relates to other information services and its fundamental concept. The mission of an IAC is considered in the light of its users or peer group how unpublished information is obtained and used and

how feedback helps the IAC achieve its mission Two non-government supported IAC are described along with one government center Also considered are operational aspects (administration and management) of an IAC Based on close contact with over a dozen operating IAC s actual experiences pertaining to the recruitment and utilization of competent research scientists and engineers in information analysis work advantages of working in an IAC environment key problems in day-to-day operation and the ever present problem of money are discussed Author

N71-36382# Advisory Group for Aerospace Research and Development. Paris (France) Structures and Materials Panel
DIRECTORY OF ORGANIZATIONS, INVESTIGATORS, AND PROGRAMS IN HIGH TEMPERATURE CORROSION RESEARCH
Aug 1971 26 p
(AGARD-R-586-71) Avail NTIS
Organizations are listed together with investigators and specific research areas in the field of high temperature corrosion The list includes 178 organizations from eleven NATO countries and Spain. A category index indicates the area in which the various organizations are conducting research Two areas receiving the most attention are material behavior under corrosion and reaction kinetics and diffusion processes Author

N73-15968# Advisory Group for Aerospace Research and Development Paris (France)
THE VON KARMAN LECTURE LESSONS LEARNED AND FUTURE DIRECTIONS IN THE MANAGEMENT OF TECHNICAL PROGRAMS
Robert C Seamans Sep 1972 36 p Lecture held at Brussels, 28 Sep 1972
Avail NTIS HC $4 00
Advances in technology management learned at NASA and DOD are briefly reviewed The NASA programs involved feedback from the customer accurate assessment and control using detailed schedules of tasks and costs and a three-way balance between performance, schedule and cost The defense management added the condition that new systems must also be produced and operated in large numbers Illustrations are given using major new weapon, aircraft systems Competitive prototyping and future directions in military programs are described along with the application of aerospace technology to civil needs It is concluded that NATO countries must look for better ways to provide effective defense forces and meet growing civil needs Improved technology management is of critical importance and proptotype programs must be carefully selected with a minimum of duplication Papers on the challenge facing NATO the future of defense cooperation among NATO nations and technical cooperation among NATO nations are appended N E N

N73-19959# Advisory Group for Aerospace Research and Development, Paris (France)
AIR TO GROUND TARGET ACQUISITION
Nov 1972 170 p refs Presented at AGARD Aerospace Med Panel Specialist Meeting, Brussels, Belgium, 31 May - 1 Jun 1972
(AGARD-CP-100) Avail NTIS HC $10 50
The fifteen papers and ensuing discussions presented at the AGARD Aerospace Medical Panel Specialist Meeting on Air to Ground Target Acquisition held in Brussels Belgium on the 31st May and 1st June 1972 are reported The papers cover theoretical and practical aspects of visual search and detection including the effects of complex backgrounds, illumination and contrast, and the application of mathematical modeling techniques to the solution of target acquisition problems For individual titles, see N73-19960 through N73-19974

N73-19960 North American Rockwell Corp Anaheim, Calif
THE LIKELIHOOD OF LOOKING AT A TARGET
Charles P Greening *In* AGARD Air to Ground Target Acquisition Nov. 1972 6 p (For availability see N73-19959 10-34)
Visual search behavior is characterized by brief glimpses of the terrain, separated by rapid eye movements, or saccades The likelihood of looking at a target with any particular glimpse is, in most models of search behavior, assumed to result from either random motion or a mechanically systematic search pattern. In the present study, it is assumed that the observer uses extra-foveal vision to evaluate the terrain before each saccade, to maximize the likelihood of looking at the target Quantitative data on extra-foveal search, obtained in a different context by Williams, show that such behavior is lawful and predictable The results are here applied to dynamic air-to-ground yielding target acquisition predictions which compare favorably with those obtained by other methods Author

N73-19961 British Aircraft Corp (Operating) Ltd., Bristol (England) Guided Weapons Div
MODELING OF RANDOM HUMAN VISUAL SEARCH PERFORMANCE BASED ON THE PHYSICAL PROPERTIES OF THE EYE
Ian Overington *In* AGARD Air to Ground Target Acquisition Nov 1972 12 p refs (For availability see N73-19959 10-34)
The physical properties of the eye lens and retina together with the involuntary eye movements (tremor and drift) are considered as the basic factors defining single glimpse detection probability Introduction of the concept of convolution of object profiles with the spread function of the eye lens which allows extension of such single glimpse predictions to unsharp objects is discussed along with the effects of atmospheric attenuation and range dependency of subtended size Using this comprehensive formula for single glimpse probability as an input a cumulative search probability model is developed for random search which takes account of search field of view, visual lobe effects and the transition from single glimpse to multiple glimpse situation at any part of the field of view Author

N73-19962 British Aircraft Corp. (Operating) Ltd, Bristol (England) Guided Weapons Div
THE K FACTOR IN AIR-TO-GROUND ACQUISITION MODELLING
O G Silverthorn *In* AGARD Air to Ground Target Acquisition Nov 1972 14 p refs (For availability see N73-19959 10-34)
This paper illustrates that correspondence obtained between the shapes of the probability-range curves is good both for field and simulated field detection data, but that actual performance levels are much lower than predicted A degradation factor (the K factor) has been introduced to cover this discrepancy and a similar fudge factor has been invoked to cover differences between simulated and direct field trial data The paper examines the factors on which K is dependent and describes relevant experiments and the associated attempts at modelling them It is at once a progress statement and an indication of the necessary further studies Author

N73-19963 Nottingham Univ (England) Dept of Psychology
CALCULATION AND SIMULATION OF THE EFFECTS OF TWO COMPLEX SEARCH SITUATIONS
C I Howarth, J R Bloomfield, and M E Dewey *In* AGARD Air to Ground Target Acquisition Nov 1972 12 p refs (For availability see N73-19959 10-34)
Two attempts were made to elucidate complex search situations In the first, using Howarth and Bloomfield's theoretical work as a basis, calculations were made of the cumulative search time data likely to occur when a target that was an extreme example of a distribution of objects was presented among a sample of these objects The calculations covered variations in (1) the target-nontarget cut-off point, (2) the size of the visual lobe area associated with the target, and (3) the response time that was necessary after a target was located The second, a simulation study making use of the Monte Carlo method, treated a situation in which a number of targets were presented among many nontarget objects A single target, which had a small visual lobe area associated with it was presented with a variable number of targets with large visual lobe areas The size of the visual lobe areas associated with the two kinds of target was varied, as were the number of the large lobe area targets and the length of the response times necessary after a target had been

located The likely effect of these variations on the time needed to locate the single target is reported In general, more time was needed the smaller the lobe area of the single target is reported In general, more time was needed the smaller the lobe area of the single target, the greater the lobe area of the large lobe targets, the greater the number of the latter present, and the longer the response times The cumulative curves obtained changed in shape as the four variables altered in these directions. The change in shape is likely to be found with human observers who adopt the most suitable strategy for locating the small lobe area target. Author

N73-19964 British Aircraft Corp (Operating) Ltd, Bristol (England) Guided Weapons Div
THE EFFECT OF COMPLEX BACKGROUNDS ON ACQUISITION PERFORMANCE
M B Brown *In* AGARD Air to Ground Target Acquisition Nov 1972 6 p refs (For availability see N73-19959 10-34)

The relationship between the subjective effect of structured target backgrounds on acquisition performance and physical attributes of the scene luminance structure was investigated both theoretically and experimentally The theoretical attempts are described to classify various aspects of complexity, and an experiment was carried out using synthetic target material The results showed that certain targets are more easily recognized than others for all the complex backgrounds used, and also indicated that recognition may be regarded as the detection of detail A large variability between subjects was observed. Part of this variation can be attributed to eyesight differences and to experience Author

N73-19965 Nottingham Univ (England) Dept of Psychology
PERIPHERAL ACUITY WITH COMPLEX STIMULI AT TWO VIEWING DISTANCES
J R Bloomfield *In* AGARD Air to Ground Target Acquisition Nov 1972 10 p refs (For availability see N73-19959 10-34)

Visual acuity is defined in terms of the minimum resolvable visual angle or its reciprocal This assumes, implicitly, that acuity is independent of viewing distance In the current study, this assumption was tested for peripheral acuity using two viewing distances A complex visual display was used for the acuity task The display contained a regular 17 by 10 arrangement of discs The display was exposed for 0 25 seconds, with the observer fixating a particular point in it Measurements were made of the threshold distance from the fixation point at which a single, smaller target disc could be detected The data, obtained from eight observers, supported the assumption that peripheral acuity is independent of viewing distance, the threshold distance remaining unchanged for four sizes of target, in spite of the large change in viewing distance This implies that performance in air-to-ground target acquisition should not be directly affected by variations in viewing distance Author

N73-19966 Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt Oberpfaffenhofen (West Germany)
A MODEL FOR THE INHERENT CONTRAST CONDITIONS IN FULL-FORM OBJECTS
Max R Nagel *In* AGARD Air to Ground Target Acquisition Nov 1972 21 p refs (For availability see N73-19959 10-34)

The concept was developed of a simple model that is representative of the luminance and contrast conditions on full-form objects A reasonably realistic approach is a sphere that is exposed to the irradiation from the entire sky, the sun, and the ground, taking into account the considerable variation of the luminance in the sky Based primarily on measurements of the sky luminance in the Pikes Peak region of Colorado, U S A , calculations were made of the inherent contrast in such a model when it is viewed from any direction with fields of view of various sizes Other calculations were concerned with the model object's contour contrast against its background and with its color Representative results of these calculations are shown and discussed Author

N73-19967 Scripps Institution of Oceanography, San Diego, Calif Visibility Lab
AIR-TO-GROUND VISIBILITY OF LIGHTS AT LOW BACKGROUND LEVELS
John H Taylor *In* AGARD Air to Ground Target Acquisition Nov 1972 8 p refs (For availability see N73-19959 10-34)

After sunset and before sunrise the visual task of the airborne observer becomes radically different from that which he must perform during the daylight hours The range at which targets will be seen depends upon the physical properties of the source, such as its intensity and color, the length of time for which it is exposed to view, the transmissivity of the atmospheric path of sight, and the visual performance capabilities of the observer This paper describes some new data which apply to this problem, and suggests that the relationship between visibility and flash duration may be somewhat more complex than has usually been assumed The results have application to both aggressive and defensive needs, and are of interest to the signalling community in general Author

N73-19968 Air Force Systems Command, Wright-Patterson AFB, Ohio Flight Environments Branch
AIR-TO-GROUND TARGET ACQUISITION WITH FLARE ILLUMINATION
Robert L Hilgendorf IN AGARD Air to Ground Target Acquisition Nov 1972 11 p refs (For availability see N73-19959 10-34)

This paper is concerned with the results from three recent experiments Experiment 1 dealt with the effect of shielding a 25,000,000-lumen flare source and determining the optimal number of flares to be used for a given target area No statistically significant effect was found due to flare shielding For the given target area simulated, it appeared that there was no additional benefit derived from igniting more than two flares over a simulated area of about 1 5 kilometers by 5 kilometers Experiment 2 dealt with shielding of a 60,000,000 lumen source, and again, no statistically significant effect was found due to the flare shielding Experiment 3 dealt with the visual acuity under simulated flare light In this experiment each of eight groups of five subjects performed simulated observer altitude ranging in 152 meter increments from 152 to 1,219 meters For the slant ranges simulated (1,029 to 1,587 meters), 610 meters was the best altitude for visual performance Like the other findings, this could have significant impact on tactical planning for night missions The parameters of this study have now been blown-up to real-world size and the Aerospace Medical Research Laboratory, in conjunction with the Air Force Armament Laboratory, is conducting flight tests to validate the altitude data of the experimental simulations Author

N73-19969 Army Aeromedical Research Lab Fort Rucker, Ala
AIR TO GROUND TARGET ACQUISITION
Robert W Bailey *In* AGARD Air to Ground Target Acquisition Nov 1972 5 p refs (For availability see N73-19959 10-34)

Biomedical problems with the helmet mounted sight and visual target acquisition system are discussed in terms of sighting errors in the laboratory and in flight for still and moving targets The effects of this type optical device on depth and spatial perception are presented along with suggested bioengineering techniques for improving the system F O S

N73-19970 Army Electronics Command, Fort Monmouth, N J Avionics Lab
A DESIGN CONCEPT FOR A DUAL HELICOPTER NIGHT SCOUT SYSTEM
William J Kenneally *In* AGARD Air to Ground Target Acquisition Nov 1972 11 p refs (For availability see N73-19959 10-34)

Limited but promising operational experience with helicopter borne night vision systems (both low light level TV and forward looking infrared) has spurred an interest in the application of night vision technology to second generation airborne systems The limited quantitative performance data on these first generation systems, coupled with the significant advances in night vision technology made during the intervening period, place severe

restrictions on the system designer attempting to make logical system tradeoffs. The scope of the paper is to examine various relevant data on the subject and to develop a design concept for such a second generation scout system. Author

N73-19971 Aeronautical Systems Div., Wright-Patterson AFB, Ohio
REALISTIC CONSIDERATIONS OF TARGET ACQUISITION ON LINES OF COMMUNICATIONS
Roy K. Frick, Diane E. Summers, and Thomas E. Tyson *In* AGARD Air to Ground Target Acquisition Nov 1972 10 p refs (For availability see N73-19959 10-34)

An approach is presented to determining the probability of acquiring targets by a search aircraft which flies along an enemy line of communication (LOC). A line of communication is defined as a route, e.g., a road, waterway, or railroad, and the targets of interest are trucks, boats, or other appropriate carriers. The analysis approach consists of three areas of investigation: (1) analyzing the contour (twists and turns) of a route for purposes of establishing a preferred flight path plus determining the frequency distributions of LOC aspects relative to this flight path, (2) computing the probability of detecting a target, given a set of LOC, target, and flight path conditions, and (3) integrating the results of the first two areas of investigation to produce the probability of target acquisition for the overall set of conditions. The methodology presented can be applied to investigate conditions of target acquisition for existing lines of communication in the real world. Author

N73-19972 University of Technology, Leicester (England). Dept of Ergonomics and Cybernetics
THE EFFECTS OF BRIEFING ON TELEVISUAL TARGET ACQUISITION
K. R. Parkes *In* AGARD Air to Ground Target Acquisition Nov 1972 9 p refs (For availability see N73-19959 10-34)

Evidence from a number of studies indicates that the nature of the briefing information available to the observer has a marked effect on target acquisition performance. Low-level forward oblique photographs of the target and surrounding terrain have been found to be a particularly effective form of briefing information, but such photographs may not always be available. In the experiment reported, an evaluation was made of the extent to which, in the absence of suitable oblique photographs, perspective representations of the target and surrounding terrain, derived from maps, facilitated televisual target acquisition performance. The effectiveness of these perspective views, used as briefing material in addition to maps, was compared with that of maps used alone, and maps used together with oblique photographs. The results show that, while not as effective as oblique photographs, the perspective views brought about some improvement in performance as compared with the maps alone. Author

N73-19973 British Aircraft Corp (Operating) Ltd., Bristol (England). Guided Weapons Div.
THE USE OF KELLY'S REPERTORY GRID TECHNIQUE FOR ASSESSING SUBJECTIVE ESTIMATES OF IMPORTANT PARAMETERS FOR TARGET ACQUISITION
A. J. Mitchell *In* AGARD Air to Ground Target Acquisition Nov 1972 12 p refs (For availability see N73-19959 10-34)

Kelly's Repertory Grid Technique was employed to study the area of subjective factors involved in visual acquisition of targets, in the hope of covering the discrepancy between the data obtained from psychophysical studies and actual field data. Two experiments were conducted using highly trained aircrew which have led to the definition of some subjective parameters and estimates of their importance. Through analysis three major overlying components were elicited. These major components were: (1) The target has visual prominence against the background (2) The target is in a helpful built-up environment or Target is in an urban environment (3) There are geographical and map identification features around the target to aid acquisition. Author

N73-19974 British Aircraft Corp (Operating) Ltd., Bristol (England). Guided Weapons Div.
SOME PSYCHOMETRICS IN RELATION TO TARGET ACQUISITION
Sandra J. Seale *In* AGARD Air to Ground Target Acquisition Nov. 1972 7 p refs (For availability see N73-19959 10-34)

The variance associated with acquisition performance arises from between subject differences and within subjects differences. A recent intensive study was conducted, using a pattern discrimination test, the Witkin Embedded Figures Test (EFT). Previous experimental work using this test indicated that it would be suitable for the target acquisition situation in that it would estimate analytical ability, which was hypothesized as being a factor contributing to the variation in acquisition performance. Although no overall significance was found between EFT scores and measures of acquisition performance under various briefing conditions, the study highlighted the difficulties involved in using psychometric tests in the context of target acquisition. The paper examines these difficulties and illustrates the contribution to the methodology in this area. Author

N73-20959 Advisory Group for Aerospace Research and Development, Paris (France)
AGARD GERMAN COOPERATION
Frank Wattendorf *In* DFVLR Management in Sci and Technol Sep 1971 p 80-87 (For availability see N73-20955 11-34)

Dr Theodor Benecke's activities and accomplishments as Chairman of the Advisory Group for Aerospace Research and Development at AGARD NATO are described. Typical cooperation projects for mutual benefit constituted development of V/STOL aircraft, low altitude defense, Transall, G 91, F 104 G, and the German-French Research Institute at St Louis, France. G.G.

N73-21881# Advisory Group for Aerospace Research and Development, Paris (France)
THE 1972 AGARD ANNUAL MEETING COMMEMORATING AGARD'S TWENTIETH ANNIVERSARY
28 Sep 1972 112 p In FRENCH and ENGLISH Meeting held at Brussels, 28 Sep 1972
Avail NTIS HC $7.75

Proceedings of the AGARD meeting are reported. Belgian research and development programs presented include some Belgian contributions to aerospace techniques, structures and materials research in Belgium, and fluid dynamic research in Belgium. A lecture on lessons learned and future directions in the management of technical programs was also presented. F.O.S.

N74-17664# Advisory Group for Aerospace Research and Development, Paris (France)
DIRECTORY OF RESEARCH ACTIVITIES ON IN-SITU COMPOSITES
Oct 1973 21 p refs Prepared by Battelle Columbus Labs (AGARD-R-609) Avail NTIS HC $3.25

A directory of research facilities, laboratories, and corporations conducting research on composite materials is presented. The organizations are identified by the country in which located and the principal respondents are identified. A brief statement concerning the type of research being conducted accompanies each entry where applicable. Author

N74-21610# Advisory Group for Aerospace Research and Development, Paris (France)
AGARD ANNUAL MEETING, 1973
Dec 1973 68 p refs In ENGLISH partly in FRENCH Conf held at Athens, 13 Sep 1973
Avail NTIS HC $6.50

Conference papers are presented which relate to (1) research and development activities in Greece, and (2) the use of science and technology to meet military requirements at reduced costs. For individual titles, see N74-21611 through N74-21618

N74-216.1 Advisory Group for Aerospace Research and Development, Paris (France)
RESEARCH AND DEVELOPMENT ACTIVITIES IN GREECE
S N Moraitis (Hellenic Air Force) *In its* AGARD Ann Meeting, 1973 Dec 1973 p 8-13 (For availability see N74-21610 12-34)

An overview is presented of the distribution of research efforts in Greece according to the areas of activity and expenditures. Tables are given which illustrate the following (1) the activities which contributed to the formation of the national income for the years 1970 through 1972, and secondly the forecasts for 1987, (2) the country's gross domestic asset formation per field of productive activity, (3) electric power exploitation as achieved by the Public Power Corporation, (4) the structure of domestic asset formation in the industrial enterprises for four categories of products, (5) distribution of expenditures for types of research and the percent of the gross national product represented by the total research expenditure, and (6) the financing of research and development according to the performing agency for the current five year program which runs from 1973 to 1977
D L G

N74-21612 Athens Univ (Greece)
ELECTRONICS AND SPACE ACTIVITIES IN GREECE
K Anastassiades *In* AGARD AGARD Ann Meeting, 1973 Dec 1973 p 14-17 In ENGLISH and FRENCH (For availability see N74-21610 12-34)

The role of electronics and space activities in scientific research is discussed. Emphasis is placed on a study of wave propagation conditions between two points in magnetic conjunction, Athens and Salisbury, Rhodesia. Some results are presented which were obtained in a special space research program to study the overall electron content simultaneously between the two points. The results were observed during the solar eclipse of 30 June 1973
D L G

N74-21613 Societe Nationale Industrielle Aerospatiale, Paris (France)
TECHNIQUES ORIENTED TOWARDS COST REDUCTION
M Chevalier *In* AGARD AGARD Ann Meeting, 1973 Dec 1973 p 22-27 In ENGLISH and FRENCH (For availability see N74-21610 12-34)

It is pointed out that parallel to the continuous improvement in performance regarding aircraft construction, actions are currently being developed towards simpler materials, open to quantity production, and characterized by a determined tendency towards economy. Three aspects are dealt with concerning the vehicle production (1) structure (2) power plants and (3) equipment
Author

N74-21614 National Aerospace Lab, Amsterdam (Netherlands)
TECHNICAL AND OPERATIONAL ASPECTS OF EXTERNALLY MOUNTED AIRCRAFT EQUIPMENT
T VanOosterom *In* AGARD AGARD Ann Meeting, 1973 Dec 1973 p 29-34 (For availability see N74-21610 12-34)

It is pointed out that the installation of additional equipment in an aircraft is often impossible due to space limitations. Consideration is given the choice which must be made between redesigning or modifying the fuselage or housing the equipment in an external speedpack or pod. Several advantages of a pod mounted system are indicated and specific design aspects which may require advanced applications of science and technology are discussed. It is concluded that the pod concept has the potential to solve in many cases, the problems inherent in the implementation of new operational equipment within the inventory of an air force. It is also concluded that for many applications the pod concept will have a superior operational cost effectiveness in comparison with an aircraft integrated system
Author

N74-21615 Ministry of Defence, London (England)
THE REDUCTION OF AIRFRAME COSTS WITH PARTICULAR REFERENCE TO COMBAT AIRCRAFT
J Seddon *In* AGARD AGARD Ann Meeting 1973 Dec 1973 p 34-39 (For availability see N74-21610 12-34)

It is stated that for modern aircraft weapon systems such as a multi-role combat aircraft, cost reduction can be achieved at all stages of the procurement process, and by a wide variety of means. Some examples are presented of recent achievements in the following three phases aerodynamic and structural design, mechanical and physical engineering, and manufacturing technology
Author

N74-21616 Ministry of Defence (West Germany)
THE HINGELESS ROTOR A CONCEPT TO INCREASE MISSION EFFECTIVENESS AT REDUCED COSTS
F Barth *In* AGARD AGARD Ann Meeting 1973 Dec 1973 p 40-50 refs (For availability see N74-21610 12-34)

The mechanical simplification of helicopters by elimination of blade attachment hinges is discussed. Emphasis is placed on the Bolkow system which features fiberglass rotor blades of high elasticity rigidly attached to a stiff hub. The stated advantages of the system are (1) The hingeless rotor design needs only about 30 percent of the parts of an articulated rotor (2) Control becomes more powerful, faster and more direct, and nearly independent of thrust (3) The rotor blades can offer more than 10,000 hours of service life compared to 1 000 to 2,000 hours for comparable helicopters (4) The fiberglass material is corrosion proof and tests have shown that it is insensitive to notches (5) The hingeless rotor is most promising in fulfilling modern military requirements for air mobility
D L G

N74-21617 Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France)
RESEARCH WORK AND COSTS. THE ROLE OF DATA PROCESSING
P Bohn *In* AGARD AGARD Ann Meeting 1973 Dec 1973 p 51-53 In ENGLISH and FRENCH (For availability see N74-21610 12-34)

An overview is presented on research work and costs in aircraft manufacturing with emphasis placed on the changes which have taken place as a result of the introduction of powerful computers. It is pointed out that computers provide a means to improve the modelling of physical phenomena and to demonstrate the resulting effects on the whole aircraft. Aircraft manufacturers are now in a position to achieve trade-offs which were at one time inconceivable, especially as far as costs are concerned. It is predicted that in the future, research work will require more highly trained engineers, extremely powerful computers, and very bulky data files. These requirements are based on (1) In-flight development time is becoming increasingly short, and is devoted more and more either to the development of electronic systems, or to the analysis of abnormal flight patterns or failure investigations (2) Official agencies and industrial firms everywhere must more and more frequently accept contracts for the development of prototypes (3) Optimization, Obtained by computers, permits the manufacturer to simplify without incurring any penalties as regards the objectives
D L G

N74-21618 Air Force Systems Command, Wright-Patterson AFB, Ohio
IMPACT OF TECHNOLOGY ON COST REDUCTION
John F Brooke *In* AGARD AGARD Ann Meeting 1973 Dec 1973 p 53-60 (For availability see N74-21610 12-34)

The results are discussed of a United States Air Force survey conducted to identify those technologies which hold the greatest promise of reducing life-cycle costs. The analysis indicates that the cost reducing aspects of seventeen identified technologies could achieve a ten year life cycle savings on the order of $450 million. Five of these technologies considered to be representative examples are discussed in detail and include (1) advanced composites (2) weldbond joining (3) metal working and munitions, (4) replaceable tread tire concept and (5) aircraft battery technology
D L G

N74-22492# Advisory Group for Aerospace Research and Development, Paris (France)
DIRECTOR S ANNUAL REPORT, 1970, TO THE NATO MILITARY COMMITTEE
Apr 1971 80 p
Avail NTIS HC $7 00

A summary of AGARD's 1970 technical program is presented. Meetings, publications, personnel, and budgeting for this reporting period are discussed. Author

N74-23493# Advisory Group for Aerospace Research and Development, Paris (France)
THE AGARD CHARTER
1 May 1971 17 p In ENGLISH and FRENCH
Avail NTIS HC $4.00

The charter, as authorized by the North Atlantic Military Committee document dated 5 April 1971, is presented in the original English version and in its French Translation. D.L.G.

N74-23494# Advisory Group for Aerospace Research and Development, Paris (France)
THE 1971 AGARD ANNUAL MEETING
Dec 1971 78 p Meeting held at Nord-Torpa, Norway, 8 Sep 1971
Avail NTIS HC $7.00

The conference held in Nord-Torpa, Norway, 8 September 1971 is reported. The theme of the First Plenary Session was Norwegian Industrial and Defense Research Development, and the theme of the second session was Status and Trends in International Aerospace Cooperation. The presentation of each speaker is included. Author

N74-23495# Advisory Group for Aerospace Research and Development, Paris (France)
INTERNATIONAL CONFERENCE MANAGEMENT
George Zinnemann Jan 1972 18 p Revised
Avail NTIS HC $4.00

Some guidelines are presented for individuals involved in managing and participating in international conferences. The material is divided into four sections, each of particular significance to the project officer, the host organization, the meeting chairman and the speakers, respectively. D.L.G.

N74-23496# Advisory Group for Aerospace Research and Development, Paris (France)
DIRECTOR'S ANNUAL REPORT TO THE NORTH ATLANTIC MILITARY COMMITTEE, 1971
Mar 1972 82 p
Avail NTIS HC $7.25

The report has been prepared in the context of the total AGARD 1971 Technical Program which is carried out by the AGARD Panels, the Consultant and Exchange Program, and the Military Committee Studies Program. The achievements are reported in terms of (1) the meeting which were held to bring together the leading personalities of the NATO nations in a particular field of science and technology for the common benefit of the NATO community, (2) the AGARD Series publication which were distributed and or initiated as a result of these meetings for the purpose of assisting member nations in the effective use of their research and development capabilities, (3) the personnel that planned for and participated in the total program, and (4) the budget that supported this stimulus to the advances in the aerospace sciences relevant to strengthening the common defense posture. The Appendix contains the detailed program of the individual activities. Author

N74-23497# Advisory Group for Aerospace Research and Development, Paris (France)
AGARD HANDBOOK (INCLUDING AGARD BY-LAWS)
Sep 1972 31 p Revised
Avail NTIS HC $4.75

A handbook which presents an overview of the AGARD organizational structure is presented. Topics include historical background, military studies program, panels and publications. The bylaws of AGARD are presented for reference purposes. S.K.W.

N74-23498# Advisory Group for Aerospace Research and Development, Paris (France)
HIGHLIGHTS: AGARD'S TWENTIETH ANNIVERSARY, 1952 - 1972
1972 29 p
Avail NTIS HC $4.50

The first issue of AGARD's Highlights is presented. Changes and developments which have taken place since the establishment of AGARD in 1952 are detailed. Biographies are presented of the recipients of the first Von Karman Medals. S.K.W.

N74-23499# Advisory Group for Aerospace Research and Development, Paris (France)
DIRECTOR'S ANNUAL REPORT TO THE NORTH ATLANTIC MILITARY COMMITTEE, 1972
1972 80 p
Avail NTIS HC $6.00

Abstracts for AGARD series publications for 1972 are presented. Proceedings of panel meetings in the following subject areas are detailed: avionics, electromagnetic wave propagation, flight mechanics, fluid dynamics, guidance and control, propulsion and energetics, and structure and materials. A list of AGARD consultants and their subject specialties is also presented. S.K.W.

N74-23500# Advisory Group for Aerospace Research and Development, Paris (France)
HIGHLIGHTS, SPRING 1973
1973 32 p
Avail NTIS HC $4.75

Short articles on the progress and activities of AGARD panels are presented. Panels are included in the areas of avionics, electromagnetic wave propagation, flight mechanics, and structures and materials. A summary of the work completed on the new AGARD multilingual aeronautical dictionary is included along with a description of the plans for the publication of the collected works of Theodore Von Karman. K.M.M.

N74-23501# Advisory Group for Aerospace Research and Development, Paris (France)
INSTRUCTIONS TO AUTHORS OF AGARD MANUSCRIPTS TO BE SET BY THE PRINTERS. INSTRUCTIONS TO AUTHORS OF AGARD MANUSCRIPTS TO BE PREPARED CAMERA READY [INSTRUCTIONS A L'INTENTION DES AUTEURS DE MANUSCRITS AGARD DESTINEES A ETRE COMPOSE PAR L'IMPRIMEUR. INSTURCTIONS AUX AUTEURS DE MANUSCRITS DE PUBLICATIONS AGARD DESTINEES A ETRE REPRODUITS PAR PHOTOGRAHIE DIRECTE]
Oct 1973 8 p Revised In ENGLISH and FRENCH
Avail NTIS HC $4.00

Instructions are given for those who are unable to use AGARD special layout paper for the preparation of manuscripts for AGARD publication. Also presented are the instructions for those who are preparing manuscripts for publication using the direct reproduction system. K.M.M.

X74-73503 Advisory Group for Aerospace Research and Development, Paris (France)
SMALL TACTICAL MISSILES FOR 1980 AND BEYOND. VOLUME 1: SUMMARY [LES PETITS MISSILES TACTIQUES A L'HORIZON 1980 ET AU DELA. TOME 1: SOMMAIRE]
Roger Marquet and Charles Bouquard Dec 1973 60 p In FRENCH
(AGARD-AR-57-1-Vol-1)

NATO Confidential Report

The case is made in this report for a NATO approach to tactical missile developments for the 1980s via technology programmes which lead into building block programmes and major sub-systems having application to more than one missile system and then for linking together these various separate development programmes into a planned development programme of the [illegible].
Based on a comprehensive survey of the advances in sub-system technologies and supporting techniques which will be available by 1980-1985 and on the estimated characteristics of the target of the 1980s, this method of approach lead to the definition of some 80 conceptual system designs corresponding 41

missile system types classified into 7 target oriented missile families. These conceptual system designs are analyzed in order to derive the cases for commonality and modularity and the most promising technologies and techniques for the 1980's.

X74-73504 Advisory Group for Aerospace Research and Development, Paris (France)
SMALL TACTICAL MISSILES FOR 1980 AND BEYOND. VOLUME 1: EXECUTIVE SUMMARY
Roger Marquet and Charles Borgeaud Dec. 1973 56 p
(AGARD-AR-57-Vol-1)
NATO Confidential Report

For abstract, see X74-73503

X74-73505 Advisory Group for Aerospace Research and Development, Paris (France)
SMALL TACTICAL MISSILES FOR 1980 AND BEYOND, VOLUME 2
Roger Marquet and Charles Borgeaud Dec. 1973 242 p
(AGARD-AR-57-Vol-2)
NATO Secret Report

For abstract, see X74-73503

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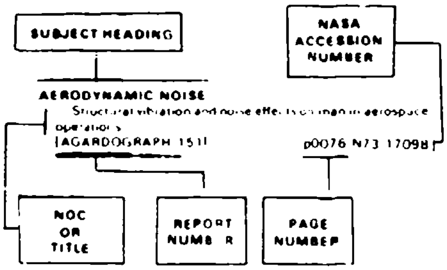

The subject heading is the key to the subject content of the document. A brief description of the document, e.g., title plus a title extension, or Notation of Content (NOC), is included for each subject entry to indicate the subject heading context. these descriptions are arranged under each subject heading in ascending accession number order. The report number helps to indicate the type of document cited. The page number identifies the page in the abstract section (Part I) on which the citation appears. The NASA accession number denotes the number by which the citation is identified on that page.

A

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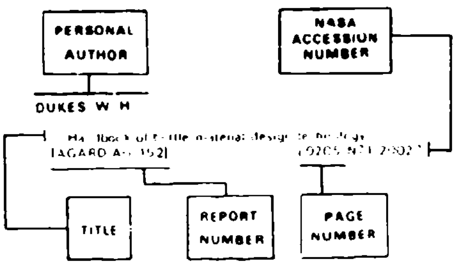

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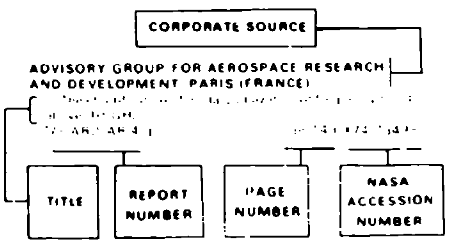

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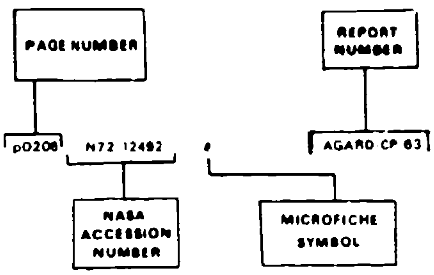

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